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ABSTRACT

This bibliography is intended to offer research paths for geography educators interested in geography learning. It includes research on all three general modes of geographic learning: spatial learning, map learning, and formal geography learning. Chapter 1, "Introduction," contains the following: (1) "What is geography and what is geography learning?" (2) "Structure of the Bibliography"; (3) "Purposes of the Bibliography"; and (4) "What is included in the bibliography and what is not." Chapter 2, "Commentary on Research Paths and Suggestions for Future Research," contains the following: (1) "Spatial learning"; (2) "Map learning"; (3) "Formal geography learning"; and (4) "Affective geography learning." Chapter 3, "Bibliography," lists the following: (1) "Spatial Learning: Research Studies"; (2) "Spatial Learning: Reviews of Research"; (3) "Map Learning: Research Studies"; (4) "Map Learning: Reviews of Research"; (5) "Formal Geography Learning: Research Studies"; (6) "Formal Geography Learning: Reviews of Research"; (7) "Affective Geography Learning"; (8) "Overview: Geography Education"; (9) "Overview: Social Studies Education"; and (10) "Overview: Learning Theory and Educational Strategies." A section titled "A Postscript on Methodology" is included. (EH)

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PATHWAYS IN GEOGRAPHY
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: National Council for
›graphic Education

Learning Geography: An Annotated Bibliography of Research Paths

Alfred S. Forsyth, Jr.

Prepared in cooperation with the
Committee on Research and External Relations

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Alfred S. Forsyth, Jr.

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Learning Geography: An Annotated Bibliography of Research Paths

Alfred S. Forsyth, Jr.

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Foreword

How Geographers Learn about How People Learn Geography

Geographers are (supposedly) indefatigable explorers of places. We are people for whom maps are invitations to travel afield and afar. That somewhat romanticized view of who we are and what we do has considerable merit in thinking about research endeavors closer to home. Nothing can be closer to home, nothing more important to us, than helping to foster new generations of geographers.

Al Forsyth's contribution to the PATHWAYS series fits the title exactly: it offers research paths for geography educators interested in geography learning. The pleasure of reading an annotated bibliography is akin to the chance to look over someone's shoulder while he or she is working, to read their research notes, and to say: "Hey, that's interesting. I hadn't seen that before," where *that* could be a particular source, a novel interpretation of a source you know well, or the provocative juxtaposition of sources that you had not encountered before. For me, Al Forsyth's section headings have already had just that effect: The Affective Learning literature is intriguing. Maybe I should go back and look at...

The annotated bibliography is itself an example of one of his three modes of geographic learning: we can learn from external sources of information during the process of formal education. My only regret is that he did not publish this bibliography two years ago. It would have helped the National Geography Standards writers immensely. It will make all the difference in the future if we are willing to make sure that these do not once again become the road(s) not taken (with apologies to Robert Frost). *Learning Geography* is a vital piece of scholarship. Pick up Forsyth's challenge and explore a path. As he writes, "the more we know about learning, the more we know about how to educate."

Roger M. Downs
The Pennsylvania State University

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1

Introduction

As its stature rises within the educational community, geography education increasingly commands local, regional and national attention. Through the work of the Geographic Education National Implementation Project (GENIP), the National Geographic Society Alliances for Geographic Education, National Council for Geographic Education, American Geographical Society, Association of American Geographers, and other efforts, increasing importance is given to geography's place in the curriculum. Recently, geography was named one of the core subjects in the national *America 2000* proposal and the subsequent *Goals 2000: Educate America Act*. It has been a focal subject of the National Assessment for Educational Progress. *Geography for Life: National Geography Standards 1994* is now completed, with its world-class standards.

Geography educators have much to celebrate in the progress that has been made so rapidly. They express concern that further development may be hampered by lack of a solid theoretical foundation and sense of *where we are now* that permit concerted forward movement in a sensible direction (Downs, 1994). Geography educators are in danger of overleaping our support base of research and data. It is always easier to build the vehicle and decide on the route to take *before* beginning the journey.

To continue to progress and to improve geography learning for life, those doing research on geography education and geography educators need a baseline, a sense of where we are regarding how young people learn geography. What does the research tell us about how people learn geography? Where is it helpful? Where is it lacking? The principal aim of this bibliography is to provide such a baseline, by presenting a comprehensive view of relevant research on how people learn geography. As the curricular focus evolves from the *five fundamental themes* (Joint Committee 1984) to the national geography standards, a knowledge of what we know—and do not know—about geography learning may provide some welcome guidance. In choosing paths to follow in geography education, it may help to know the paths the research has already followed.

What is geography and what is geography learning?

For the purposes of this bibliography, I define geography broadly as the study of, or the acquisition of, knowledge of the spatial distribution and interaction of phenomena on or near the surface of the Earth. Geography comprises our understanding of where things are, why they are there, and the importance of those locations relative to others. The distinction between intentional, active study and less structured, sometimes passive acquisition of knowledge hints that geography is something that people learn both directly, in formal instructional settings, and indirectly, outside of school and throughout their lives.

The research indicates that we seem to learn geography in three principal ways, from three information sources. First, we learn from our spatial environment. We are all *born geographers*. As animals alive and functioning in a spatial environment, we develop a sense of spatial awareness in various ways during our everyday lives. We form mental representations or *cognitive maps* of real-world space that influence how we get on with the business of living.

Second, we learn by studying and using *representations* of our spatial environment, principally maps but also photographs and written descriptions and narratives. We learn, therefore, by examining spatial relationships second-hand, vicariously. Whereas in spatial learning we form our individual images of the environment through direct interaction, in map learning we rely on abstract representations of that environment. We interpret information that others structure graphically or verbally.

The third way of learning geography is through formal education, from teachers, textbooks, and instructional activities and materials. This likely involves considerable map learning—and it could even involve spatial learning—but others, principally teachers, prescribe the procedures for gaining knowledge or changing attitudes. Teachers control and guide the various processes of in-school learning.

Structure of the Bibliography

This bibliography includes research on all three general modes of geographic learning. It lists research on *spatial learning,* how people directly acquire knowledge of their physical environment sufficient for effective functioning. The research examines the formation of mental spatial representations the learner creates from exploring the local environment or from non-formalized learning about distant environments. Spatial learning research examines how cognitive maps of those environments are formed, the nature of those images, and how those images affect other aspects of peoples lives. As subjective environmental perception overlaps considerably with spatial learning, I have also included research on this topic. For the purposes of this bibiliography, spatial learning includes conceptions about any aspects of the spatial environment (e.g., weather, the Earth) that children form *prior to* formal education.

It seems reasonable that learning about one's environment from symbolic representations of that environment made by others might differ in nature from unaided spatial learning. Maps are so important to geography and such a strong, time-honored focus of research that this bibliography lists *map learning* research separately. The research included in this section focuses on how people learn from maps and how they extract and process information at different developmental stages, rather than on how specific teaching strategies increase map learning skills.

Formal geography learning usually takes place in geography or social studies classes. This bibliography lists research on how young people learn geography from teachers who employ various instructional strategies and materials. In fact, this section presents research focusing on anything in the formal school setting that helps young people learn geography.

Geography learning is more than increased cognition: it involves the effect of such learning (or lack of it) on the attitudes and values of young people. The bibliography, therefore, lists separately the small body of research on *affective geography learning*, the nature and development of values and attitudes toward other peoples and places.

Each of these major sections of the bibliography is divided into *research studies*, individual investigations of geography learning that advance our cumulative knowledge base, and comprehensive *reviews of research*, summarizing the body of work along a particular research path. The latter include, in addition to comprehensive reviews, a small number of particularly elucidative essays or opinion pieces that have firm grounding in relevant research.

Annotations are provided for the research studies in the bibliography but are not given for the reviews of research. In most cases, the focus of a review is evident from its title. Furthermore, the breadth of most reviews makes meaningful, concise annotation impossible.

As the nature of geography learning varies with the characteristics of the learner, it is important to know who the subjects are in research studies in order to increase the generalizability of the findings. Therefore, wherever possible the annotation indicates the *research population* for the study. (Unless otherwise noted, subjects are from the United States.)

Although each of the major sections of the bibliography—spatial learning, map learning, formal geography learning, and affective geography learning—could be divided into more specific topics, this was not done because so many of the research studies and reviews of research in each section bridge several topics. The confusion caused by such overlapping among studies and topics would reduce the usability of the bibliography. Were this a computer database rather than a written document, perhaps this would not be the case. I further believe that the intellectual synergy gained from inspecting the broad range of studies under the each major heading would be lost if categories were drawn too narrowly.

Following the major substantive sections of the bibliography are three, more general sections. The first, listing the most comprehensive summaries of *general geography education* research, should aid the researcher in acquiring an overview of the broad field of geography education and help in situating new research endeavors.

Geography in formal education is usually part of the social studies. Reviews of research in *social studies education* are presented in the next section, therefore, for the light they may shed on geography learning.

Finally, to give the geography researcher a baseline understanding of *learning theory and educational strategies* in general, helpful background references on these topics are listed.

Purposes of the Bibliography

- *Dimensions:* To reveal the overall breadth and depth of existing research in the field of geography learning.
- *Directions:* To delineate the research paths that have been taken on geography learning.
- *Connections:* By bringing together in one collection research on disparate aspects of geography learning, to point out relationships between kinds of research that might not have been previously associated with each other (e.g., spatial learning and classroom instruction).

Ultimately, the intention of this work is to improve geographic education. The more we know about how young people learn geography, the better we can provide effective education. The more we know about learning, the more we know about how to educate.

What is included in the Bibliography and what is not

- Research that sheds light on *how* young people learn geography is included; research that surveys *how much* geography has been learned is not included unless the process involved in that learning is also critically examined. Suffice it to say that many surveys over the years have assessed the amount and nature of geography learning, usually pointing out deficiencies in that learning. Although these efforts provide valuable information for certain purposes in geography education, they do not often enlighten us about how geography learning takes place. In most cases these studies focus on description of end-products, not the means or processes involved in getting there.
- Works such as those delineating geography curricula, new ways of teaching, lesson plans and activities, instructional materials, and methods of assessment, are not included unless they have a firm and clear research basis about how young people learn geography.

2

Commentary on Research Paths and Suggestions for Future Research

A perusal of the entries in each section of the bibliography gives a general picture of the nature of research on those topics and its current state of health. As a group, the studies are not usually cohesive enough to be called a research *agenda*, but most point in the same direction. The researchers all seem to be on the same research *path*. Sometimes alternate routes to the same research goal are evident. Discontinuities along the paths suggest opportunities for future research.

Spatial learning

This is a prominent and well-traveled research path, highly trodden since the 1970s. In fact, the body of research in this area is so large relative to other aspects of geographic learning that *research superhighway* is probably a more appropriate term than path. The travelers on this route are mostly cognitive and developmental psychologists, not educators. Much of the research is incremental, with narrowly-focused experimental studies adding minutely to the ever-growing body of findings. The cumulative works of several researchers who investigate spatial learning (e.g., Anooshian, Blaut, Golledge, Herman, and Siegel *et al.*, Liben and Downs, Matthews, Thorndyke, and Goldin, Vosniadou) are cohesive enough to be called *research agendas*.

Unfortunately for geography education, most spatial learning research is basic research: its intent is to discover how people learn in a particular domain, with little or no concern for the educational applications. Further, the research findings of the psychologists are not being applied to education by curriculum developers or other educators. If more *educators* engaged in spatial learning research perhaps their research would be more applied, less strictly theoretical. In particular, educators could investigate early spatial learning (e.g., during play in preschool) with an eye to determining how early geographic learning (i.e., the prerequisities for formal education) occurs. In that way findings on spatial learning might be applied to design formal education. Conversely, it is up to geography educators to interpret the findings of the psychologists in order to inform sound educational decisions.

Future research paths in spatial learning might include:

- How can findings about spatial learning be applied to formal geographic education?
- How effective are spatial learning strategies and activities in helping students achieve curricular goals in geography? (A related question is: Should curricular goals for geography include spatial learning goals?)
- Regarding conception studies (e.g., child's conception of weather [Stepans and Kuehn 1985]) and perception studies (e.g., child's perception of rivers [Wilson and Goodwin 1981]), *how* do children gain these conceptions and perceptions? The few existing studies tend to be descriptive, not explanatory.
- Do memory for spatial location of objects in the near environment and memory for relative locations of places in the larger environment differ? Are they related? Do large-scale and small-scale visuo-spatial memory processes differ?
- How are spatial learning via live exploration and spatial learning learning via simulated exploration (e.g., interactive videodisc) related? How is each affected by the use of maps? Of aerial photographs?
- Is learning in a virtual reality environment different from other spatial learning?
- What is the relationship among proficiency with videogames (often involving simulated travel), spatial ability, and spatial learning?
- What is the nature of learning from different kinds of travel children might engage in (e.g., family vacations, school bus rides, bicycling around a neighborhood)? What are the important variables in this kind of learning?
- Much literature evokes considerable interest in adults' *sense of place*. What is the nature of children's sense of place and how does it affect spatial learning?
- How are spatial learning and learning about time related? (A related question: How are learning geography and learning history related?)
- Is creative ability or imagination related to spatial learning ability?
- Are psychomotor abilities related to spatial learning ability?
- With all the research on this kind of learning, surprisingly little attention has been paid to individual differences other than gender. How do the results of each of these studies differ with different populations? Related to this, is there any effect of single parent families, increased mobility or other currently prominent sociological variables on spatial learning and sense of place in children?
- A research path is just beginning on the nature and development of expertise in geography (e.g., Downs and Liben 1991): How is expertise in spatial learning attained and how is it different from average competency?

Map learning

This clearly-marked and well-used research path is also traveled by educators and psychologists alike. It is a more meandering path than that of spatial learning research, comprising a mixture of basic and applied, experimental and action or empirical research. Although fewer clear research agendas exist in map learning than in spatial learning, the bodies of work of Blades *et al.*, Kulhavy *et al.*, and (earlier) Towler are impressive.

The preponderance of research in geography education has been on maps and mapping. Research focuses on: characteristics of learners that affect map learning, qualities of maps that either promote or obstruct learning, or procedures or strategies employed by individual learners. Many studies, several recent, have appeared on the relationship between map and text learning. Nearly all studies include implications or suggestions for education, and several report on the effectiveness of training in map learning.

The influence of the work of Piaget is still great: many studies (in both map learning and spatial learning, but more so in the former) are still linked conceptually to his work. Interestingly, a great deal of the research, particularly recently, concludes that children's map reading abilities have been underestimated in the past, that Piaget's developmental framework was too conservative.

Future research paths in map learning might include:

- How can we apply the research findings on map learning in formal geography education?
- What kinds of map learning strategies are most effective for which populations of people? Do different populations have different map learning strategies or patterns of map skill development?
- Many kinds of maps exist, designed for many purposes. How does map learning differ with different kinds of maps (e.g., route maps vs. thematic maps)?
- What is the relationship between spatial learning and map learning? How are spatial learning and graphicacy related? Do children with high spatial ability levels learn map skills more quickly? Do children's play and other spatial learning experiences affect their ability to learn from maps? Is there a relationship between cognitive mapping ability and concrete mapping ability?
- Do personality variables such as self-esteem, egocentrism, and assertiveness correlate with successful learning from maps as opposed to learning from less abstract information sources?
- Is there a relationship between mathematical ability and map learning? Between graphic arts ability and map learning? Between computer literacy and map learning? Between proficiency with videogames (many of which involve representations of space and simulated travel) and map learning?
- How does learning from maps differ from learning from other graphic representations like diagrams or graphs?
- How do learning from aerial photographs, satellite images, and conventional maps differ? Do combinations of these formats promote map learning? How does the

coloring system of satellite images (e.g., false color, color enhancement) affect map learning for students at various levels?

- Concerning the relationship between maps and text, there is some research on how students learn from maps in textbooks and some on how maps affect learning from written text (e.g., Kulhavy in both cases), although such research by educators is lacking. In addition, how do students learn from photographs and pictures in geography texts?
- What are the guidelines for the best use of maps in textbooks to promote learning? What relationship among maps, pictures, and written text is most effective?
- In addition to maps and other graphic representations of spatial relationships, verbal representations of places abound in both written and spoken forms. How do children process and learn from written, non-textbook materials with geographic content and from oral descriptions of places? (The next section addresses textbooks.)
- Are graphics-based learning strategies like concept mapping and knowledge mapping related to geographic map learning? Does practice with concept mapping improve map learning, and vice-versa?
- What is the relationship between graphicacy and literacy? A study of individuals proficient in both, or much stronger in one than the other, might be enlightening.
- How are expert map learners different from average and poor map learners in their learning processes?
- What effect do computer mapping programs have on map learning? Are interactive map programs effective in stimulating map learning?
- How do the results of each of these studies differ with different populations?

Formal geography learning

This research path is discontinuous, more like stones that could be used to cross a stream than a route with clear direction or destination. Most studies compare instructional strategies, although these appear less popular recently, perhaps because they are so difficult to control, fraught with internal and external validity problems. Several studies have sought correlates for place location knowledge, but none recently. Other research foci include mnemonics, use of technology, learning from text-plus-maps, teacher variables, spatial organizers, and text learning

The kinds of research carried out by psychologists interested in spatial learning or map learning are very different from studies done by geography educators. The former are tight, experimental, incremental studies, often grouped in a sequence, usually clearly tied to larger agendas: the latter are looser, more fragmented, *ad hoc*, more likely to be empirical action research. Downs (1994) argues that geography education, unlike spatial learning, lacks theories around which to build bodies of research, suggesting a careful consideration of the work of Piaget, Bruner, Vygotsky, and Gardner as starting points in theory construction. Of those, only Piaget appears with any frequency as underpinning geography education research, and his developmental theories are being seriously questioned (Case 1993).

Little research is directly relevant to any of the learning goals represented by the eighteen new standards for geography education (Downs 1993). Considerable geographic learning research stresses skills, predominantly map skills, but not on the goals and objectives represented by the standards. For some of these end-products there have been studies assessing levels of attainment, but no studies have investigated how children learn particular topics or concepts. In this regard, geography differs from other curricular areas like mathematics, where much research exists on how specific topics and concepts are learned (Gregg and Leinhardt 1994). In geography education, the main impetus for research is map skills, not curricular goals that relate to the standards. It is important to know how *all* content areas in geography are learned, not just maps!

Much of the research in both spatial learning and map learning seeks to identify and understand a developmental sequence of abilities regarding geography learning. There is an assumption that a pattern of normal development exists that proceeds independent of formal instruction. Research on geography education reveals that instruction is sometimes based on research findings on *geographic development*, but often it is not. Thus most geographic education proceeds, guided by little more than intuition.

Future research paths in formal geography learning might include:

- Although a steady stream of place location studies continues, mostly surveys of place location knowledge, correlating knowledge with certain variables, the question remains, How do children learn place location? What are the cognitive processes involved? Do they differ for different populations? To use a medical analogy, geography educators are becoming quite good at assessing the patient's current state of health, but we do not know how the body works to a sufficient degree to be able to prescribe preventive measures and cures, to be a able to prescribe a healthy lifestyle.
- Psychologists use maps to study human memory and information storage. Should geography educators investigate other applications of maps in education and human learning?
- Is there a relationship between map learning and the use of *mapping surrogates*, learning and instructional strategies such as concept maps and knowledge maps, in other areas of learning? If the cognitive processes involved in each area are related, what effects, if any, should this have on geography education?
- Although developmental studies exist on spatial learning and map skills, no longitudinal studies of broader geography learning are available. What would such studies reveal about the interactions among spatial learning, map learning, affective learning, and formal education?
- Studies comparing different instructional strategies, learning strategies, or learning environments are no longer common. Difficult as they are to structure, their findings are still valuable. How do various instructional strategies, learning strategies, and learning environments differ in their effects on geography learning?
- Do students who perform well in formal geography education learn in a different manner from those who do not perform well? What different learning strategies are employed?

- Some research, mostly from educational psychologists, is available on how students learn from textbooks. It would be useful for geography educators to address how learning from textbooks and non-text instructional materials in geography takes place, especially as the range of such materials continues to expand. How do students learn from geography textbooks? How do they learn from videos? Computer simulations? Some work is appearing on learning from GIS materials, but as more computer-related technologies become available to schools, more research is needed.
- As with the other research paths, not enough attention has been paid in formal geography education research to individual differences. Any research in the future should recognize subject-treatment interactions. Replications with different populations would be valuable.

Affective geography learning

This research path, prominent in Europe in the 1950s and 1960s, has never been popular in this country and now has been virtually abandoned elsewhere. Perhaps it should be resurrected and, like Robert Frost's road not taken, should beckon future researchers. In our shrinking global village, increasingly beset with violent ethnic and racial conflicts, the need to investigate the origin and development of attitudes toward other peoples and countries—and the role for education in those processes—seems critical. Furthermore, it is a research path that parallels nicely the current emphasis on multicultural or diversity education.

Future research paths in affective geography learning might include:

- What stereotypes do young people hold of other peoples and why? After twenty years, replication of earlier descriptive studies might provide useful baseline data.
- What kinds of geography learning activities result in what kinds of attitudes and affective learning outcomes?
- Do popular media affect children's attitudes toward other countries and other peoples?
- How does travel affect peoples attitudes toward other peoples and countries? What are the important variables in educational travel (e.g., traveling companions, duration of trip, intensity of interaction with local population, degree of cultural difference)?
- How does contact with people from other countries (e.g., classroom guest speakers) affect attitudes? What are the critical variables? Do surrogate experiences (e.g., videos) have similar effects?
- What role do peer pressure and the pressure to conform play in developing attitudes toward other peoples and countries?
- Are students developing any sense of transnational identification (e.g., citizen of Earth) with the growth in environmental education and awareness?
- What is the effect of education and increased knowledge about other countries and peoples on children's early attitudes and preconceptions (e.g., replications of Stillwell and Spencer, 1974)? Longitudinal studies might be especially valuable.

- Stoltman (1972) looked at territorial decentration in children: How might this form of geography learning affect formal geography education? Replications might be elucidating.
- How are spatial learning and map learning related to formation and development of attitudes about local and distant environments? In particular, how does exploration of the near environment affect formation of such concepts as home and neighborhood?
- Research with different populations (e.g., racial and ethnic groups, different socioeconomic status, urban/suburban/rural, male/female) seems especially important on these topics, with its interpersonal emphasis.

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Joint Committee on Geographic Education, Association of American Geographers and National Council for Geographic Education. (1984) *Guidelines for Geographic Education: Elementary and Secondary Schools.* Macomb, IL and Washington, DC : National Council for Geographic Education and Association of American Geographers.

Stepans, J. and Kuehn, C. (1985). What research says: Children's conceptions of weather. *Science and Children*, 23(1), 44-47.

Stillwell, R., and Spencer, C. (1974). Children's early preferences for other nations and their subsequent acquisition of knowledge about those nations. *European Journal of Social Psychology*, 3(3), 345-349.

Stoltman, J. P. (1972, August). *Territorial decentration and geographic learning*. Paper presented at the International Geographical Congress Commission on Geography in Education, Quebec City, Canada. (ERIC Document Reproduction Service No. ED 071933).

Wilson, P., and Goodwin, M. (1981). How do twelve- and ten-year-olds perceive rivers? *Geographical Education*, 4(1), 5-16.

3

Bibliography

Spatial Learning: Research Studies

Acredolo, L. P. (1976). Frames of reference used by children for orientation in unfamiliar spaces. In G. T. Moore and R. G. Golledge (Eds.), *Environmental knowing: Theories, research, and methods* (165-172). Stroudsburg, PA: Dowden, Hutchinson, and Ross.

Three experiments to assess degree to which familiarity and differentiation affect recall of location of event. Differentiation and foreknowledge significant; familiarity not. (Preschoolers and 8-year-olds)

Acredolo, L. P., Pick, H. L., Jr., and Olsen, M. G. (1975). Environmental differentiation and familiarity as determinants of children's memory for spatial location. *Developmental Psychology*, 11(4), 495-501.

Two studies testing the hypothesis that development of spatial frames of reference proceed from egocentric to fixed to coordinated. Hypothesis not supported, but support for existence of reference systems and importance of fixed system at this level. (3-, 4-, and 10-year-olds)

Allen, G. L., Kirasic, K. C., Siegel, A. W., and Herman, J. F. (1979). Developmental issues in cognitive mapping: The selection and utilization of environmental landmarks. *Child Development*, 50, 1062-1070.

Two studies to assess developmental differences in ability to select and use environmental landmarks to determine distance. Adults and children select different landmarks; adults better at judging distances. (2nd-, 5th-graders, and college students)

Anooshian, L. J., and Kromer, M. K. (1986). Children's spatial knowledge of their school campus. *Developmental Psychology*, 22(6), 854-860.

Assessment of distance and direction knowledge using different methodologies. Distance and direction measures not comparable. (4th-, 6th-, and 8th-graders)

Anooshian, L. J., Pascal, V. U., and McCreath, H. (1984). Problem mapping before problem solving: Young children's cognitive maps and search strategies in large-scale environments. *Child Development*, 55, 1820-1834.

Measures of spatial representation closely related to age; landmark knowledge before route-order knowledge before route-scaling knowledge. (Preschoolers)

Anooshian, L. J., and Young, D. (1981). Developmental changes in cognitive maps of a familiar neighborhood. *Child Development*, 52, 341-348.

Assessment of accuracy and consistency in pointing out landmarks in neighborhood from different reference sites. High accuracy for all age levels; improvement with age in accuracy and consistency. Males outperformed females. (1st/2nd-, 4th/5th-, and 7th/8th-graders)

Appleyard, D. (1970). Styles and methods of structuring a city. *Environment and Behavior,* 100-117.

Investigation of how people relate different parts of city to each other and how they place themselves in city. Reveals different schematic methods of structuring city—associational, topological, positional—based on cognitive differences, travel mode, and familiarity. (Adults—Venezuelan)

Baird, J. C., Merrill, A. A., and Tannenbaum, J. (1979). Studies of the cognitive representation of spatial relations: II. A familiar environment. *Journal of Experimental Psychology,* 108(1), 92-98.

Assessed ability to recall locations of buildings by pairwise distance judgments and direct mapping. Accuracy equal for both methods, but subjects preferred direct map. (College students)

Beck, R., and Wood, D. (1976). Comparative developmental analysis of individual and aggregated cognitive maps of London. In G. T. Moore and R. G. Golledge (Eds.), *Environmental knowing: Theories, research, and methods* (173-184). Stroudsburg, PA: Dowden, Hutchinson and Ross.

Study of development of cognitive mapping from sketch maps drawn on third, fifth and sixth day in city. Maps show increased differentiation over time and hierarchical organization. (Adolescents)

Biel, A. (1982). Children's spatial representation of their neighborhood: A step towards a general spatial competence. *Journal of Environmental Psychology,* 2, 193-200.

Study of ability to combine perspectives of neighborhood. Evidence of unexpectedly early acquisition of projective and Euclidean concepts. Home acts as central reference point. (6-year-olds—Swedish)

Blaut, J. M., and Stea, D. (1974). Mapping at the age of three. *Journal of Geography,* 73(7), 5-9.

Subjects assembled landscape-feature toys into model of a macro-environment, then were asked to describe their environment and routes between points. All subjects were able to represent a cognitive map by a physical model; older children better able to verbalize descriptions. Evidence that cognitive mapping ability precedes Piagetian spatial learning. (3-, 4-, and 5-year olds)

Borke, H. (1975). Piaget's mountains revisited: Changes in the egocentric landscape. *Developmental Psychology,* 11(2), 240-243.

Replication of Piaget and Inhelder's experiment with modifications to insure age appropriateness of task. Evidence that very young children can understand spatial relations from other person's perspectives. (3- and 4-year olds)

Bosowski, E. F. (1981). *The formation of cognitive images of the world: An analysis of sketch maps.* Doctoral dissertation, University of Colorado, Boulder.

Analysis of sketch maps of the world. Detail and accuracy increase with age. Home a powerful concept; accuracy diminishes with distance from home. Includes analysis of places most frequently included and analysis of descriptive characteristics of subjects to find explanatory variables. (K-12th graders—many nations)

Bosowski, E. F. (1982, October). *Two comparative studies of student views of the world.* Paper presented at the annual meeting of the Middle States Division of the Association of American Geographers, Upper Montclair, NJ. (ERIC Document Reproduction Service No. ED 240039).

Analysis of sketch maps of world to examine influence of location on student perceptions. Found strong influence of home, current events, and cultural factors on map accuracy. (K-12th graders and college students—many nations)

Brewer, W. F., and Treyens, J. C. (1981). Role of schemata in memory for places. *Cognitive Psychology,* 13, 207-230.

Schema expectancy positively correlated with recall and recognition of locations of object in large-scale environment. (College students)

Brown, M. A., and Broadway, M. J. (1981). The cognitive maps of adolescents: Confusion about inter-town distances. *Professional Geographer,* 33(3), 315-325.

Amount of travel within region positively correlated with accuracy of cognitive map. Female gender positively correlated with confusion about inter-town distances regardless of amount of travel.

Byrne, R. W. (1979). Memory for urban geography. *Quarterly Journal of Experimental Psychology,* 31, 147-154.

Study of estimates of urban distances showed overestimation of length for routes in town center and routes with bends. Estimates by residents of angles between roads at junctions consistently inaccurate. (College students and adults—British)

Chase, W. G. (1982). Spatial representations of taxi drivers. In D. Rogers and J. A. Sloboda (Eds.), *The acquistion of symbolic skills* (391-405). New York: Plenum Press.

Comparison of knowledge of familiar urban environment by experts (taxi drivers) and novices (other adults). Experts have larger knowledge base, do not use a hierarchy of base and secondary street systems, do use a hierarchy of neighborhoods and regions.

Clayton, K., and Woodyard, M. (1981). The acquisition and utilization of spatial knowledge. In J. H. Harvey (Ed.), *Cognition, social behavior, and the environment* (151-161). Hillsdale, NJ: Lawrence Erlbaum.

Study of acquisition of spatial knowledge of a town by a computer travel simulation. Post-test sketch maps showed considerable learning of the town's locational geography. Majority of maps oriented according to initial orientation of computer map. Suggest strong motor component to spatial acquisition. (Adults)

Cliffer, N. J. C. (1991). *Frames of reference in spatial directions.* Doctoral dissertation, University of Minnesota.

To solve spatial tasks with different reference frames, strategies are selected based on spatial elements embedded in the tasks. (Adults)

Cohen, M. E. (1980). *The effects of environmental interaction on the structure and process of cognitive mapping.* Doctoral dissertation, Temple University.

Study of components of cognitive maps (paths, nodes, edges, districts, landmarks) of subjects with analog (map) or digital (language) way-finding preferences, from simulated travel (16mm film) and actual travel. No significant differences between way-finding groups. Different cognitive mapping tasks (free map drawing, written description, recognition, probe recall) elicit different aspects of subject's cognitive map. (Adults)

Cohen, R., Baldwin, L. M., and Sherman, R. C. (1978). Cognitive maps of a naturalistic setting. *Child Development,* 49, 1216-1218.

Analysis of distance estimates of locations in a camp setting showed that judgments were made based on ease of travel (functional distance). (9- and 10-year olds and adults)

Conning, A. M., and Byrne, R. W. (1984). Pointing to preschool children's spatial competence: A study in natural settings. *Journal of Environmental Psychology,* 4, 165-175.

Series of studies showing children may possess higher level of spatial competence than previously thought. Euclidean knowledge greater from exploration of familiar environments than non-familiar environments. (3- and 4-year-olds—Great British)

Cousins, J. H., Siegel, A. W., and Maxwell, S. E. (1983). Way finding and cognitive mapping in large-scale environments: A test of a developmental model. *Journal of Experimental Child Psychology,* 35, 1-20.

Measures of way-finding, landmark, route and configurational knowledge of school campus supported the Siegel and White hierarchical model of cognitive mapping development. Route and configurational measures strongly influenced as well by degree of familiarity with environment. (1st-, 4th-, and 7th-graders)

Crampton, J. (1992). A cognitive analysis of wayfinding expertise. *Cartographica,* 29(3 and 4), 46-65.

Comparison of expert wayfinders' (experienced orienteers) and novice wayfinders' use of topographic route maps to find locations and routes showed that experts employ an "enabling," problem-solving strategy with rich mental representations, whereas novices employ a "preventing," problem-seeking way-finding strategy. (Adults—British)

Devlin, A. S. (1976). The 'small town' cognitive map: Adjusting to a new environment. In G. T. Moore and R. G. Golledge (Eds.), *Environmental knowing: Theories, research, and methods* (58-66). Stroudsburg, PA: Dowden, Hutchinson and Ross.

Comparison of sketch maps of new city after living there two weeks and three months showed increasing importance over time of functional landmarks (vs. traditional landmarks) and of routes connecting them. (Adults—wives of military personnel)

Driever, S. L. (1983). The relationship between actual and cognitive state sizes. *Professional Cartographer*, 35(2), 165-171.

Questionnaire study found that subjects distorted state sizes logarithmically in all but eight states. Males more accurate than females in size estimation. Territoriality (distance of state from subjects' home state) not significant factor. (College students)

Evans, G. W., Marrero, D. G., and Butler, P. A. (1981). Environmental learning and cognitive mapping. *Environment and Behavior*, 13(1), 83-104.

Using sketch maps, analyzed changes in cognitive maps of novel environment as function of increased environmental experience. Results underscore importance of landmarks and of paths within the landmark network. Basic landmark network does not change with experience, but exact location does. (College students)

Feldman, A., and Acredolo, L. (1979). The effect of active versus passive exploration on memory for spatial location in children. *Child Development*, 50, 698-704.

Active exploration of environment superior to passive exploration for children at preoperational level as means of locating, and later relocating, object. No difference in children at concrete operational level. (3- and 4-year-olds; 9- and 10-year-olds)

Freundschuh, S. M. (1992). *Spatial knowledge acquisition of urban environments from maps and navigation experience.* Doctoral dissertation, State University of New York at Buffalo.

Study of map study vs. navigation for learning two kinds of urban environments (rectilinear grid street pattern and irregular street pattern) showed differences for method, type of environment (rectilinear easier to learn) and gender (males superior).

Gale, N., Golledge, R. G., Pellegrino, J. W., and Doherty, S. (1990). The acquisition and integration of route knowledge in an unfamiliar neighborhood. *Journal of Environmental Psychology*, 10, 3-25.

Comparison of neighborhood route knowledge acquired from actual field experience and from viewing a videotape. Navigation, sketch mapping, and scene recognition tasks showed mode of experience affected only navigation performance (field experience superior). (9- to 12-year-olds)

Grling, T. (1989). The role of cognitive maps in spatial decisions. *Journal of Environmental Psychology*, 9, 269-278.

Experiment examined procedures used to choose routes that minimize total travel distance among locations as function of type of spatial information (numerical distance data vs. map). Map more effective. (College students—Swedish)

Gauvain, M., and Rogoff, B. (1986). Influence of the goal on children's exploration and memory of large-scale space. *Developmental Psychology*, 22(1), 72-77.

Nature of memory of large-scale space (layout or route) depends on purpose of exploration (seeking layout knowledge or route knowledge). No age level differences. (6- and 7- year-olds; 8- and 9-year-olds)

Golbeck, S. L. (1992). Young children's memory for spatial locations in organized and unorganized rooms. *Journal of Applied Developmental Psychology*, 13, 75-96.

Two studies analyzing memory for spatial location of objects as function of logical or random arrangement of room and of knowledge of spatial operations. Performance superior for logical arrangement and for higher spatial operational level. (3- and 4-year-olds; K-2nd graders)

Goldin, S. E., and Thorndyke, P. W. (1981a). *Spatial learning and reasoning skill* (Report No. R-2805-ARMY). Santa Monica, CA: Rand Corporation. (ERIC Document Reproduction Service No. ED 215181).

Series of studies investigated alternative methods for presenting spatial knowledge, differences in individuals' ability to use those methods, and differences in strategies used to acquire knowledge. Concludes that knowledge sources should be selected on the basis of task requirements and individual abilities. (Adults)

Goldin, S. H., and Thorndyke, P. W. (1981b). *An analysis of cognitive mapping skill. A Rand Note* (Report No. N-1664-ARMY). Santa Monica, CA: Rand Corporation.

Series of five experiments to compare the performance of good and poor cognitive mappers (based on knowledge of home community) on several spatial tasks: learning a novel environment from unaided navigation, from navigation with map, from map alone; map reading and interpretation. Good cognitive mappers were superior in most tasks to poor mappers, suggesting that they encode and retain spatial information better. (Adults)

Goldin, S. H., and Thorndyke, P. W. (1981c). *Simulating navigation for spatial knowledge acquisition* (Report No. N-1675-ARMY). Santa Monica, CA: Rand Corporation.

Compares environmental learning from actual navigation (by bus) and simulated navigation (viewing a film) along an unfamiliar route. Measures of landmark and survey knowledge showed no difference between groups. Supplementary maps enhanced learning from simulated navigation. (College students)

Golledge, R. G. (1978). Learning about urban environments. In T. Carlstein, D. Parkes, and N. Thrift (Eds.), *Making sense of time* (76-98). New York: Wiley.

Development of conceptual model of learning about a novel urban environment. Comparison of cognitive configurations of city by newcomer and intermediate-length resident groups. Use of stress-values as measures of environmental learning over time. (Adults)

Golledge, R. G., Gale, N., Pellegrino, J. W., Doherty, S., and Niehaus, R. D. (1992). Spatial knowledge acquistion by children: Route learning and relational distances. *Annals of the Association of American Geographers*, 82(2), 223-244.

Examination of spatial knowledge acquisition via route learning procedures. Difficulties with distance estimation and accurate sketch mapping after successful route navigation suggest different learning procedures for route navigation and spatial knowledge acquisition. (9- to 12-year-olds)

Golledge, R. G., Ruggles, A. J., Pellegrino, J. W., and Gale, N. D. (1993). Integrating route knowledge in an unfamiliar neighborhood: Along and across route experiments. *Journal of Environmental Psychology*, 13, 293-307.

Examination of how route learning in unfamiliar environment via unidirectional or bidirectional presentations provides locational, directional, and layout information. Results show little spatial knowledge acquisition from route learning. No gender differences. (Adults)

Golledge, R. G., Smith, T. R., Pellegrino, J. W., Doherty, S., and Marshall, S. P. (1985). A conceptual model and empirical analysis of children's acquisition of spatial knowledge. *Journal of Environmental Psychology*, 5, 125-152.

Extensive review of literature on spatial cognition; development of conceptual model of acquiring, representing, and using environmental knowledge; testing of model in case study of child acquiring route knowledge in unfamiliar suburban neighborhood. (11-year-old male)

Gopal, S. C. (1988). *A computational process model of spatial navigation*. Doctoral dissertation, University of California at Santa Barbara.

Description of computational process model of spatial navigation that simulates human acquisition of environmental knowledge through navigation. (Young adults)

Hardwick, D. A., McIntyre, C. W., and Pick, H. L., Jr. (1976). The content and manipulation of cognitive maps in children and adults. *Monographs of the Society for Research in Child Development*, 41(3, Serial No. 166).

Comparison of cognitive maps of room showed accurate maps at all age levels, but only college students' maps were accurate when mental rotation or perspective-taking tasks were required. (1st- and 5th-graders and college students)

Hart, R. (1979). *Children's experience of place*. New York: Irvington Publishers.

Classic collection of studies of spatial activity, place knowledge, place values and feelings, and "place-use." Includes case studies of several families. (Many ages)

Hart, R. A. (1981). Children's spatial representation of the landscape: Lessons and questions from a field study. In L. S. Liben, A. H. Patterson, and N. Newcombe (Eds.), *Spatial representation and behavior across the life span: Theory and application* (195-236). New York: Academic Press.

Analysis of landscape models of the home environment to determine their system of reference (egocentric, fixed, or coordinated) and to relate them to Piaget's stages of spatial development. Extent and nature of environmental exploration deemed important factors. (5- to 8-year-olds)

Hazen, N. L. (1982). Spatial exploration and spatial knowledge: Individual and developmental differences in very young children. *Child Development*, 53, 826-833.

After passive navigation of a route, subjects were tested on ability to navigate on their own in reverse direction (route-reversal knowledge), on landmark-reversal knowledge, on inference knowledge, and on ability to construct a model of the environment. Found that route-reversal knowledge precedes landmark-reversal knowledge and that inference ability develops last. (3- to 6-year-olds)

Hazen, N. L., Lockman, J. J., and Pick, H. L., Jr. (1978). The development of children's representations of large-scale environments. *Child Development*, 49, 623-636.

Examines relationship between spatial exploration mode (active or passive) and cognitive representations of a museum room and a playhouse. Children who explored actively gained more accurate spatial knowledge. (20- to 28-month-olds and 36- to 44-month-olds)

Herman, J. F. (1980). Children's cognitive maps of large-scale spaces: Effects of exploration, direction, and repeated experience. *Journal of Experimental Child Psychology*, 29, 126-143.

Three experiments analyzing spatial knowledge gains from directed and free exploration of a model town. Gains greater from directed exploration. Accuracy greater for 3rd-graders. (Kindergarten and 3rd-graders)

Herman, J. F., Heins, J. A., and Cohen, D. S. (1987). Children's spatial knowledge of their neighborhood environment. *Journal of Applied Developmental Psychology*, 8, 1-15.

Subjects made bearing and distance estimates to neighborhood landmarks, then described routes among them. Found that even 6-year-olds had accurate spatial knowledge, amount of exploration increased with age, boys explored more than girls, sophisticated way-finding strategies not evident. (6-, 8- and 10-year-olds)

Herman, J. F., Kail, R. V., and Siegel, A. W. (1979). Cognitive maps of a college campus: A new look at freshman orientation. *Bulletin of the Psychonomic Society*, 13(3), 183-186.

Tests of spatial knowledge over time showed that knowledge was very good after only a short period, increased up to three months, then leveled off. Males outscored females in landmark knowledge but not route or configurational.

Herman, J. F., and Siegel, A. W. (1978). The development of cognitive mapping of the large-scale environment. *Journal of Experimental Child Psychology*, 26, 389-406.

In the first study, accuracy of cognitive maps increased with repeated navigation of a model town. In the second study, viewing a real town was as effective as walking through it in generating accurate cognitive maps. (Kindergarten and 5th-graders)

Hill, M., and Rodgers, J. (1985). *Cognitive maps of a college campus: A multidimensional scaling analysis.* Paper presented at the 31st Annual Convention of the Southwestern Psychological Association, Austin, TX. (ERIC Document Reproduction Service No. ED 267352).

Various spatial knowledge measures showed no gender difference in configurational knowledge, males superior in distance estimates.

Hintzman, D. L., O'Dell, C. S., and Arndt, D. R. (1981). Orientation in cognitive maps. *Cognitive Psychology*, 13, 149-206.

Series of 14 experiments investigating ability to point to landmarks in environment from various orientations found that cognitive maps are not holistic, but rather orientation-specific representations.

Hirtle, S. C., and Hudson, J. (1991). Acquisition of spatial knowledge for routes. *Journal of Environmental Psychology*, 11, 335-345.

Experiment contrasts route knowledge and configurational knowledge acquisition via a map or a slide presentaiton. Results showed that maps are better for configurational knowledge, that either method works well for route knowledge, and that individual differences were greatest in the slide group.

Holyoak, K. J., and Mah, W. A. (1982). Cognitive reference points in judgments of symbolic magnitude. *Cognitive Psychology*, 14, 328-352.

Four studies of inferred relative locations of cities along a west-east axis from Pacific coast to Atlantic coast. Found that speed and accuracy depended on which coast is specificed as the reference point and that distances between cities are subjectively stretched for near-to-home cities. (College students)

Houghton, D. M., and Morgan, V. (1974). Children's reasoning about their environment. *Journal of Geography*, 73(5), 5-10.

Investigation of how children impose order on the concrete and abstract features of their environment by finding meaningful relationships among them. (6- to 7-year-olds)

Kahl, H. B., Herman, J. F., and Klein, C. A. (1984). Distance distortions in children's cognitive maps: An examination of the information storage model. *Journal of Experimental Child Psychology*, 38(1), 134-146.

Found that distance estimates are exaggerrated for "segmented" routes through various areas of a school as opposed to "unsegmented" or direct, homogeneous routes; and that the overestimations are a function of developmental age. (2nd-, 4th-, and 6th-graders)

Kaplan, R. (1976). Way-finding in the natural environment. In G. T. Moore and R. G. Golledge (Eds.), *Environmental knowing: Theories, research, and methods* (46-57). Stroudsburg, PA: Dowden, Hutchinson and Ross.

Four studies: 1) sketch maps after route navigation were pictorial, linear, or regional in nature; 2) boys explored more extensively than girls in a board game simulation of environmental exploration; 3) prior cognitive structuring for outdoor exploration, in the form of games, can improve spatial knowledge acquisition; 4) contour maps and photo-based maps have different strengths as preparation for way-finding experiences. (Junior high school and college students)

Kirasic, K. C., Allen, G. L., and Siegel, A. W. (1984). Expression of configurational knowledge of large-scale environments: Students' performance of cognitive tasks. *Environment and Behavior*, 16(6), 687-712.

Upperclassmen outscored freshmen on perspective-taking task involving their campus; no differences on distance and direction tasks. In general, no gender differences. (College students)

Klatzky, R. L., Loomis, J. M., Golledge, R. G., Cicinelli, J. G., Doherty, S., and Pellegrino, J. W. (1990). Acquisition of route and survey knowledge in the absence of vision. *Journal of Motor Behavior*, 22(1), 19-43.

Analysis of route navigation and reproduction abilities of blindoflded individuals showed considerable spatial ability in the absence of visual cues. (Adults)

Klett, F. R., and Alpaugh, D. (1976). Environmental learning and large-scale environments. In G. T. Moore and R. G. Golledge (Eds.), *Environmental knowing: Theories, research, and methods* (121-130). Stroudsburg, PA: Dowden, Hutchinson and Ross.

Two studies of sketch drawings of community analyzed for scale, perspective, and abstraction showed increased sophistication of 3rd- and 4th-graders' representations over 1st-graders', but a decrease from 3rd to 4th grade. Small sample sizes. (1st-, 3rd-, and 4th-graders)

Kosslyn, S. M., Pick, H. L., Jr., and Fariello, G. R. (1974). Cognitive maps in children and men. *Child Development*, 45, 707-716.

Analysis of distance estimations between objects separated by opaque barrier, transparent barrier or no barrier showed that children exaggerate distances if barriers are present more than adults do. (Preschoolers and adults)

Ladd, F. C. (1970). Black youths view their environment. *Environment and Behavior*, 2(1), 74-99.

Analysis of neighborhood sketch maps and verbal descriptions of neighborhhood, housing, and travels showed four main kinds of maps (pictorial, schematic, diagrammatic, and map-like), unrelated to subject differences. Content of "mental maps" provides sociological data. (Adolescents)

Landau, B., Spelke, E., and Gleitman, H. (1984). Spatial knowledge in a young blind child. *Cognition*, 16, 225-260.

Eight experiments involving blind and sighted blindfolded children show that blind children have systems of spatial knowledge with rules and principles for processing geometric information that enable successful navigation. (2-year-olds)

Lanegran, D. A., Snowfield, J. G., and Laurent, A. (1970). Retarded children and the concepts of distance and direction. *Journal of Geography*, 69, 157-160.

Study of spatial knowledge acquistion abilities of educable mentally retarded and trainable mentally retarded boys showed that distance and direction concepts can be taught and that intelligence appears not to be a controlling factors in most cases. (8- to 17-year-old boys—learning disabled)

Liben, L. S., and Downs, R. M. (1986, May). *Perspective-taking in Piagetian and Pennsylvanian landscapes*. Paper presented at the 16th annual Jean Piaget Society Symposium, Philadelphia. (ERIC Document Reproduction Service No. ED 275392).

Study of reproduction of spatial layout seen from different orientations showed that accurate reproduction is easier when the original and the reproduction are aligned. (Kindergarten-2nd-graders)

Liben, L. S., Moore, M. L., and Golbeck, S. L. (1982). Preschoolers' knowledge of their classroom environment: Evidence from small-scale and life-size spatial tasks. *Child Development*, 53, 1275-1284.

Performance in reconstructing layout of classroom was superior with life-sized furniture in actual classroom than with small-scale model. (3- to 5-year-olds and female college students)

Linn, M. C., and Petersen, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, 56, 1479-1498.

Found that sex differences may exist for some types of spatial ability but not others; that large differences are found only for mental rotation tasks; that smaller differences are found for spatial perception tasks; and that sex differences, when found, can be detected across the life span. (All ages)

Lloyd, P. (1985, July). *The ability to communicate route directions by telephone: A comparison of the performance of 7-year-olds, 10-year-olds and adults*. Paper presented at the biennial meeting of the International Society for the Study of Behavioural Development, Tours, France.

Study found developmental differences in sophistication of route direction-giving skill. (British)

Lloyd, R. (1989). Cognitive maps: Encoding and decoding information. *Annals of the Association of American Geographers*, 79(1), 101-124.

Comparison of learning a city via direct experience or navigating through it with a map showed that the latter produces a more accurate cognitive map and that location of landmarks was easier with respect to central rather than peripheral reference points. (College students)

Lord, F. E. (1941). A study of spatial orientation of children. *Journal of Educational Research*, 34(7), 481-505.

Investigated orientation with reference to directions in space, orientation with reference to nearby cities, orientation within the community, and ability to maintain orientation during travel. Found that children do not have a well-generalized knowledge of cardinal directions or accurate sense of orientation in space. (4th- through 8th-graders)

Maki, R. H., W.S. Maki, J., and Marsh, L. G. (1977). Processing locational and orientational information. *Memory and Cognition*, 5(5), 602-612.

Experiments analyzing time required to determine if statements about relative location or orientation of a learned spatial arrangement (e.g., map of U.S. states) are true or false, as indicators of how locational and orientational information is processed. (College students)

Matthews, M. H. (1981). Children's perception of urban distance. *Area*, 4, 333-343.

Study of distance and walking time estimates between points in a familiar environment. Results indicate a complex relationship between age and distance perception. (11- to 18-year-olds—British)

Matthews, M. H. (1984a). Cognitive mapping abilities of young boys and girls. *Geography*, 69, 327-336.

Analysis of free-recall maps of home area show gender differences: boys' maps are more complex, more extensive, more accurate and more sophisticated cartographically. (6- to 11-year-olds—British)

Matthews, M. H. (1984b). Cognitive maps: A comparison of graphic and iconic techniques. *Area*, 16(1), 33-40.

Comparison of effect of different spatial representation techniques (free-recall sketching, large-scale plans, aerial photographs) on children's ability to externalize about a familiar environment. Findings suggest that choice of technique depends on purpose of the externatization. (6- to 11-year-olds—British)

Matthews, M. H. (1984c). Environmental cognition of young children: Images of journey to school and home area. *Transactions of the Institute of British Geographers (New Series)*, 9, 89-105.

Analysis of free-recall maps showed that spatial knowledge acquisition increases with age, but not linearly, and that children learn about different environments in different ways. (6- to 11-year-olds—British)

Matthews, M. H. (1985a). Environmental capability of the very young: Some implications for environmental education in primary schools. *Educational Review*, 37(3), 327-339.

Comparison of children's descriptions of their journey from home to school by means of free-recall sketch interpretation, map interpretation, aerial photograph interpretation, and unaided. Found that children have well-developed sense of place at an early age. (6- and 7-year-olds—British)

Matthews, M. H. (1985b). Young children's representations of the environment: A comparison of techniques. *Journal of Environmental Psychology*, 5, 261-278.

Study of ways in which children represent journey from home to school by free-recall mapping, verbal description, interpretation of large-scale plans, and aerial photographs. (6- to 11-year-olds—British)

Matthews, M. H. (1986). The influence of gender on the environmental cognition of young boys and girls. *Journal of Genetic Psychology*, 147(3), 295-302.

Analysis of free-recall maps of home area indicated gender difference in awareness of place and spatial representation ability. Boys' performance superior on most measures. (6- to 11-year-olds—British)

Matthews, M. H. (1987). Sex differences in spatial competence: The ability of young children to map 'primed' unfamiliar environments. *Educational Psychology*, 7(2), 77-90.

Analysis of sketch maps drawn after visiting an unfamiliar area showed that although "priming" reduced sex differences in performance, boys outperfomred girls on more complex tasks. (8- to 11-year-olds—British)

Maurer, R., and Baxter, J. C. (1972). Images of the neighborhood and city among Black-, Anglo-, and Mexican-American children. *Environment and Behavior*, 4, 351-388.

Study of children's "mental pictures" of their world, through map drawings and descriptions, showed home-centeredness of Black children, greater environmental complexity for Anglo children, great variation among Mexican-Americans. (Adolescents)

McGuiness, D., and Sparks, J. (1983). Cognitive styles and cognitive maps: Sex differences in representations of a familiar terrain. *Journal of Mental Imagery*, 7(2), 91-100.

McNamara, T. P. (1986). Mental representations of spatial relations. *Cognitive Psychology*, 18, 87-121.

Investigation of method of mental representation of spatial relations (hierarchical, partially hierarchical, nonhierarchical) by having subjects learn locations of objects in spatial layouts or locations on maps of layouts and then completing item recognition, direction, and distance tasks. Support found for partially hierarchical method. (College students)

Miller, H. G. (1977). *Systematic training for development of spatial abilities among preschool children: An experimental study*. Doctoral dissertation, George Peabody College for Teachers.

Administration of a spatial abilities training program resulted in increases in ability for boys and girls equally. (Kindergarteners)

Miller, J. W. (1967). Measuring perspective ability. *Journal of Geography*, 167-171.

After studying photographs of a model of an island group, subjects indicated on the model the perspective from which the photograph had been taken. Results support Piagetian spatial developmental theory. (Kindergarten through 6th-graders)

Moore, G. T. (1975). Spatial relations ability and developmental levels of urban cognitive mapping: A research note. *Man-Environment Systems*, 5(4), 247-248.

Study explored relationship between general intelligence scores (verbal reasoning and numerical ability) and spatial relations ability scores and accuracy of sketch maps of a familiar area. Results showed no relationship for intelligence but strong relationship for spatial relations ability. (15- to 19-year-olds)

Murray, D., and Spencer, C. (1979). Individual differences in the drawing of cognitive maps: The effects of geographical mobility, strength of mental imagery and basic graphic ability. *Transactions of the Institute of British Geographers (New Series)*, 4, 374-385.

Subjects of differing mobility levels (airline pilots, college students, coal miners) were asked to draw five kinds of maps (local, town, route between home and work, region, world) which were analyzed for organization, spatial/sequential accuracy, features, and complexity. Found geographical mobility and drawing ability significantly related to cognitive map drawing performance; imaging ability not significantly related. (College students and adults—British)

Nerlove, S. B., Munroe, R. H., and Munroe, R. L. (1971). Effect of environmental experience on spatial ability: A replication. *Journal of Social Psychology*, 84, 3-10.

In general, children's extent of environmental exploration correlates positively with their performance on spatial ability tests. Boys explore more extensively than girls. (5- to 8-year-olds—African)

Nussbaum, J. (1979). Children's conceptions of the earth as a cosmic body: A cross age study. *Science Education*, 63(1), 83-93.

Replication of Nussbaum (1976). Results suggest that Earth concept develops in steps from egocentric to scientific notions through cognitive accommodation in order to assimilate newly acquired information. (4th- through 8th-graders—Israeli)

Nussbaum, J., and Novak, J. D. (1976). An assessment of children's concepts of the Earth utilizing structured interviews. *Science Education*, 60(4), 535-550.

From analysis of children's notions of an Earth concept, suggested that several notions exist and that children learn the concept Earth in a series of steps from notion to notion rather than in one conceptual leap. (2nd-graders)

O'Neill, M. (1991). A biologically based model of spatial cognition and wayfinding. *Journal of Environmental Psychology*, 11, 299-320.

Examination of computer and biological metaphors for spatial cognition in experiments comparing sketchmap performance after simulated and actual wayfinding. No significant differences between methods of wayfinding.

Perry, M. D., and Wolf, D. P. (1986). *Mapping symbolic development*. Paper presented at the 16th Annual Symposium of the Jean Piaget Society, Philadelphia. (ERIC Document Reproduction Service No. ED 270233).

Study of development of mapping as distinct from drawing. Subjects observed model of a town, then made a three-dimensional copy of the model, then made a map of the town. Found wide variation in map-drawing ability among subjects with equal modeling ability. (Kindergarten through 2nd-graders)

Pocock, D. C. D. (1976). A comment on images derived from invitation-to-map exercises. *Professional Geographer*, 28, 148-152.

Analysis of sketch maps of local community with respect to map features (buildings, landmarks, linear places, areas) and subject characteristics. (Adults—British)

Presson, C. C., and Ihrig, L. H. (1982). Using mother as a spatial landmark: Evidence against egocentric coding in infancy. *Developmental Psychology*, 18(5), 699-703.

Study concludes that infants use location of mother as a spatial landmark or reference point in addition to egocentrism. (9-month-olds)

Rand, D., Towler, J., and Feldhausen, J. (1976). Geographical knowledge as measured by Piaget's spatial stages. In J. P. Stoltman (Ed.), *International research in geographical education: Spatial stages development in children and teacher classroom style in geography (Research reports prepared in conjunction with the 23rd Congress of the International Geographical Union)* (61-78). Kalamazoo: Western Michigan University.

Replication of Rand (1973). Findings indicate strong positive correlation between class inclusion abilities and Piagetian geographic stages. Questions accuracy of Piaget's stage-age level correspondence, with few subjects at proposed transition stage. (6- to 12-year-olds)

Rand, D. C., and Towler, J. O. (1973, November). *Piaget's geographical spatial stages: An examination of their relationship to elementary children's classification-class inclusion abilities.* Paper presented at the 59th annual meeting of the National Council for Geographic Education, Washington. (ERIC Document Reproduction Service No. ED 086616).

Results indicate significant positive correlation between spatial stages and classification-class inclusion abilities, with age the only significant personal variable, supporting Piaget. (6- to 12-year-olds)

Rovine, M. J., and Weisman, G. D. (1989). Sketch-map variables as predictors of way-finding performance. *Journal of Environmental Psychology*, 9, 217-232.

After a walking tour of a town, subjects drew sketch maps, then were asked to walk to eight landmarks. Among several variables, sketch map characteristics were the best predictors of way-finding performance. (Adults)

Saarinen, T. F. (1988). Centering of mental maps of the world. *National Geographic Research*, 4(1), 112-127.

Found that sketch maps of the world are centered in three main ways—Eurocentric, Sinocentric, and Americentric, based on individual's longitudinal location and lingering European colonial influence. (College students—many nations)

Schumann-Hengsteler, R. (1992). The development of visuo-spatial memory: How to remember location. *International Journal of Behavioral Development*, 15(4), 455-471.

Found age-dependent improvement of memory for location of objects. (5- to 10-year-olds and 4- to 6-year-olds—German)

Sell, J. L. (1983). *Territoriality and children's experience of the neighborhood.* Doctoral dissertation, The University of Arizona.

Investigation of children's conception of neighborhood by examining territorial dimensions of boundedness, activities, control, social relations and identity. (4th- through 6th-graders)

Sheridan, J. M. (1968). Children's awareness of physical geography. *Journal of Geography*, 67, 82-86.

Survey of children's knowledge of physical geography concepts prior to formal instruction showed partial awareness of most concepts, focused on "striking features," and including concepts beyond the local environment. Boys outscored girls; those with kindergarten experience outscored those without. (1st-graders)

Siegel, A. W., Herman, J. F., Allen, G. L., and Kirasic, K. C. (1979). The development of cognitive maps of large- and small-scale spaces. *Child Development*, 50, 582-585.

After trips through large-scale model town, subjects constructed large- or small-scale replica. Accuracy increased with developmental level and number of trips. Same-scale replicas were more accurate. (Kindergarteners, 2nd- and 5th-graders)

Siegel, A. W., and Schadler, M. (1977). The development of young children's spatial representations of their classrooms. *Child Development*, 48, 388-394.

Subjects constructed three-dimensional models of classroom, scored for absolute accuracy, local relational accuracy, and global relational accuracy. Boys' models were more accurate than girls'. Provision of landmarks to one group of subjects increased accuracy. (Kindergarteners)

Sneider, C., and Pulos, S. (1983). Children's cosmographies: Understanding the Earth's shape and gravity. *Science Education*, 67(2), 205-221.

Interview study showed that children acquire Earth's shape and gravity concepts gradually, through stages, and that verbal ability differences are critical. (3rd- through 8th-graders)

Spencer, C., and Darvizeh, Z. (1983). Young children's place descriptions, maps and route-finding: A comparison of nursery school children in Iran and Britain. *International Journal of Early Childhood*, 15, 26-31.

Via semi-structured interviews, drawing tasks and route-finding performance subjects were compared on knowledge of local neighborhood and strategies for learning and retracing routes. (3- and 4-year-olds—British and Iranian)

Stepans, J., and Kuehn, C. (1985). What research says: Children's conceptions of weather. *Science and Children*, 23(1), 44-47.

Interview study showed most children are at a stage of nonreligious finalism in their understanding of weather cocnepts. (2nd- and 5th-graders)

Stevens, A., and Coupe, P. (1978). Distortions in judged spatial relations. *Cognitive Psychology*, 10, 422-437.

Four studies found that people have difficulty judging geographical relations between locations that are in different geographical or political units. Proposes model of hierarchical storage of spatial information. (College students)

Stoltman, J. P. (1971). *Children's conception of territory: A study of Piaget's spatial stages*. Doctoral dissertation, University of Georgia.

Test of Piaget's theory of territorial decentration with American children between ages six and twelve showed later onset of decentration than Piaget (Swiss) or Jahoda (Scottish) found; significant differences for race; no significant differences for gender or rural-urban residence. (1st- through 6th-graders)

Stoltman, J. P. (1977). Children's conceptions of space and territorial relationships. *Social Education*, 41(2), 142-145.

See Stoltman (1971)

Thorndyke, P. W., and Goldin, S. E. (1981). *Ability differences and cognitive mapping skill.* Santa Monica, CA: Rand Corporation. (ERIC Document Reproduction Service No. ED 218351).

Comparison of good and poor cognitive mappers based on accuracy of knowledge about local community. General spatial ability, visualization ability, spatial orientation ability, visual memory, and field independence distinguished good mappers from poor. (Adults)

Trowbridge, C. C. (1913). On fundamental methods of orientation and 'imaginary maps'. *Science*, 38(990), 888-897.

Study recorded subjects' perceived directions for three distant cities and the North Pole, then categorized seven types of "imaginary maps" based on data. (College students)

Verhetsel, A. (1990). De wereld in ons hoofd. Een onderwijsexperiment in verband met het ruimtelijke voorstellings en strutureringsvermogen [The world in one's head: A research experiment in connection with the ability to construct mental spatial representations]. *Pedagogische Studien*, 67(6), 261-270.

By means of tasks and interviews, study investigates how solution of spatial problems reveals mental organization of spatial knowledge. (12- and 18-year-olds and geography teachers—Dutch)

Vosniadou, S., and Brewer, W. F. (1989). *The concept of the Earth's shape: A study of conceptual change in childhood* (Technical Report No. 467). Urbana: University of Illinois Center for the Study of Reading. (ERIC Document Reproduction Service No. ED 320756).

Structured interviews revealed that children hold inconsistent concepts of the Earth's shape and gravity. Suggests that children construct assimilatory concepts to reconcile information from adults with their own naive empirical evidence. (1st-, 3rd- and 5th-graders)

Vosniadou, S., and Brewer, W. F. (1990). *A cross-cultural investigation of children's conceptions about the Earth, the Sun and the Moon: Greek and American data* (Technical Report No. 497). Urbana: University of Illinois Center for the Study of Reading. (ERIC Document Reproduction Service No. ED 318627).

Both Greek and American children held similar concepts about the Earth and the day/night cycle and both modified concepts to conform to accepted scientific notions in similar fashion. (Elementary students—Greek and American)

Vosniadou, S., and Brewer, W. F. (1992). Mental models of the Earth: A study of conceptual change in childhood. *Cognitive Psychology*, 24, 535-585.

Interviews with subjects revealed inconsistent conceptualizations, yielding five alternative mental models of the Earth. Transitions among models occur as children accommodate their notions to newly-acquired information. (1st-, 3rd- and 5th graders)

Walmsley, D. J., and Epps, W. R. (1988). Do humans have an innate sense of direction? *Geography*, 73, 31-40.

Data on indicated direction of origin from blindfolded subjects driven on a circuitous bus trip suggests an innate sense of direction, with females outperforming males and accuracy increasing with age. (Young children through adult—Australian)

Ward, S. L., Newcombe, N., and Overton, W. F. (1985, March). *Sex differences in direction giving: A study of preference and competence.* Paper presented at the annual meeting of the Eastern Psychological Association, Boston. (ERIC Document Reproduction Service No. ED 260358).

Subjects were given several direction-giving tasks and scored on use of cardinality, relational terms, mention of landmarks, mention of distance, and omission and commission errors. Males used more cardinal directions and distance indicators and committed fewer errors than females. (College students)

Webley, P. (1981). Sex differences in home range and cognitive maps in eight-year-old children. *Journal of Environmental Psychology,* 1, 293-302.

Males were found to have larger home range and more complete home area cognitive maps than females. However, no differences were found in cognitive maps of more limited areas to which both sexes had equal exposure. (British)

Webley, P., and Whalley, A. (1987). Sex differences in children's environmental cognition. *Journal of Social Psychology,* 127(2), 223-225.

Assessed cognitive maps of an unfamiliar area after route navigation by analyzing sketch maps for range and accuracy and by having subjects point to five landmarks from three reference points ("triangulation"). Boys showed superior performance to girls on all measures. (8-year-olds—British)

Wilson, P., and Goodwin, M. (1981). How do twelve- and ten-year-olds perceive rivers? *Geographical Education,* 4(1), 5-16.

Data analyzed included words to describe a river, detailed drawings of a river, completion of paired word sets related to rivers, and descriptive words for a local river. Comparison of responses of younger and older subjects. Generally subjects perceived rivers positively and as natural features unaltered by people. (10- and 12-year-olds—Australian)

Wilson, P., and Widt, L. (1982). How do fourteen-year-old pupils see desert landscapes? *Teaching Geography,* 8(1), 9-12.

(Australian)

Spatial Learning: Reviews of Research

Almy, M. (1970). The psychologist looks at spatial concept formation: Children's concepts of space and time. In J. M. Ball, J. E. Steinbrink, and J. P. Stoltman (Eds.), *The social sciences and geographic education: A reader* (67-81). New York: Wiley.

Altman, I., and Wohlwill, J. F. (Eds.). (1978). *Children and the environment*. New York: Plenum Press.

Anooshian, L. J., and Siegel, A. W. (1985). From cognitive to procedural mapping. In C. J. Brainerd and M. Pressley (Eds.), *Basic processes in memory development: Progress in cognitive development research* (47-102). New York: Springer-Verlag.

Beck, R. J., and Wood, D. (1976). Cognitive transformation of information from urban geographic fields to mental maps. *Environment and Behavior,* 8(2), 199-238.

Blades, M., and Spencer, C. (1988). How do children find their way through familiar and unfamiliar environments? *Environmental Education and Information*, 7(1), 1-14.

Blaut, J. M. (1969). *Studies in developmental geography*. (Place Perception Research Reports, No. 1). Worcester, MA: Clark University Graduate School of Geography.

Blaut, J. M., and Stea, D. (1969). *Place learning*. (Place Perception Research Reports, No. 4). Worcester, MA: Clark University Graduate School of Geography.

Butterworth, G. (Ed.). (1977). *The child's representation of the world*. New York: Plenum Press.

Byrne, R. W. (1982). Geographical knowledge and orientation. In A. W. Ellis (Ed.), *Normality and pathology in cognitive functions* (239-259). London: Academic Press.

Caplan, P. J., MacPherson, G. M., and Tobin, P. (1985). Do sex-related differences in spatial abilities exist? A multilevel critique with new data. *American Psychologist*, 40(7), 786-799.

Chase, W. G., and Chi, M. T. H. (1981). Cognitive skill: Implications for spatial skill in large-scale environments. In J. H. Harvey (Ed.), *Cognition, social behavior, and the environment* (111-136). Hillsdale, NJ: Lawrence Erlbaum.

Downs, R. M. (1981a). Cognitive mapping: A thematic analysis. In K. R. Cox and R. G. Golledge (Eds.), *Behavioral problems in geography revisited* (95-122). New York: Methuen.

Downs, R. M. (1981b). Maps and mappings as metaphors for spatial representation. In L. S. Liben, A. H. Patterson, and N. Newcombe (Eds.), *Spatial representation and behavior across the life span: Theory and application* (143-166). New York: Academic Press.

Downs, R. M., and Meyer, J. T. (1978). Geography and the mind: An exploration of perceptual geography. *American Behavioral Scientist*, 22(1), 59-77.

Downs, R. M., and Siegel, A. W. (1981). On mapping researchers mapping children mapping space. In L. S. Liben, A. H. Patterson, and N. Newcombe (Eds.), *Spatial representation and behavior across the life span: Theory and application* (237-248). New York: Academic Press.

Downs, R. M., and Stea, D. (Eds.). (1973). *Image and environment: Cognitive mapping and spatial behavior*. Chicago: Aldine.

Downs, R. M., and Stea, D. (1977). *Maps in minds: Reflections on cognitive mapping*. New York: Harper and Row.

Dueck, K. G. (1980). Environmental perception. In R. Choquette, J. Wolforth, and M. Villemure (Eds.), *Canadian geographical education* (89-98). Ottawa: University of Ottawa Press/Canadian Association of Geographers.

Eliot, J. (1970). Children's spatial visualization. In P. Bacon (Ed.), *Focus on geography: Key concepts and teaching strategies* (263-290). Washington, DC: National Council for the Social Studies.

Grling, T., Böök, A., and Lindberg, E. (1984). Cognitive mapping of large-scale environments. *Environment and Behavior*, 16(1), 3-34.

Gauvain, M. (1991, April). *The development of spatial thinking in everyday activity*. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Seattle. (ERIC Document Reproduction Service No. ED 336199).

Golledge, R. G. (1987). Environmental cognition. In D. Stokols and I. Altman (Eds.), *Handbook of environmental psychology* (131-174). New York: Wiley.

Golledge, R. G., and Rushton, G. (Eds.). (1976). *Spatial choice and spatial behavior: Geographic essays on the analysis of preferences and perceptions*. Columbus: Ohio State University Press.

Gould, P., and White, R. (1986). *Mental maps* (2nd ed.). Boston: Allen and Unwin.

Hart, R., and Berzok, M. (1982). Children's strategies for mapping the geographic-scale environment. In M. Potegal (Ed.), *Spatial abilities: Development and physiological foundations* (147-169). New York: Academic Press.

Heft, H., and Wohlwill, J. F. (1987). Environmental cognition in children. In D. Stokols and I. Altman (Eds.), *Handbook of environmental psychology* (175-203). New York: Wiley.

Holahan, C. J. (1982). *Environmental psychology*. New York: Random House.

Kuipers, B. (1982). The 'map in the head' metaphor. *Environment and Behavior*, 14(2), 202-220.

Liben, L. S. (1982). Children's large-scale spatial cognition: Is the measure the message? *New Directions for Child Development*, 15, 51-64.

Lynch, K. (1960). *The image of the city*. Cambridge, MA: MIT Press.

Matthews, M. H. (1986). Gender, graphicacy and geography. *Educational Review*, 38(3), 259-271.

Matthews, M. H. (1992). *Making sense of place: Children's understanding of large-scale environments*. Savage, MD: Barnes and Noble.

Miller, J. W., and Miller, H. G. (1977). Toward resolution of the spatial puzzle. *Peabody Journal of Education*, 54(3), 135-141.

Mitchell, L. S. (1934). *Young geographers: How they explore the world and how they map the world*. New York: John Day.

Moore, G. T., and Golledge, R. G. (Eds.). (1976). *Environmental knowing: Theories, research, and methods*. Stroudsburg, PA: Dowden, Hutchinson and Ross.

Piaget, J., and Inhelder, B. (1956). *The child's conception of space*. New York: Norton.

Piché, D. (1981). The spontaneous geography of the urban child. In D. T. Herbert and R. J. Johnston (Eds.), *Geography and the urban environment* (229-253). New York: Wiley.

Pick, H. L., Jr. (1972, September). *Mapping children—mapping space.* Paper presented at the 80th Annual Convention of the American Psychological Association, Honolulu. (ERIC Document Reproduction Service No. ED 076242).

Pick, H. L., Jr., and Rieser, J. J. (1982). Children's cognitive mapping. In M. Potegal (Ed.), *Spatial abilities: Development and physiological foundations* (107-128). New York: Academic Press.

Presson, C. C. (1983, May). *Beyond egocentrism: developing symbolic uses of spatial information.* Paper presented at the Annual Meeting of the Midwestern Psychological Association, Chicago. (ERIC Document Reproduction Service No. ED 234900).

Proshansky, H. M., Ittelson, W. H., and Rivlin, L. G. (Eds.). (1976). *Environmental psychology: People and their physical settings* (2nd ed.). New York: Holt, Rinehart and Winston.

Saarinen, T. F. (1976). *Environmental planning: Perception and behavior.* Boston: Houghton Mifflin.

Self, C. M., Gopal, S., Golledge, R. G., and Fenstermaker, S. (1992). Gender-related differences in spatial abilities. *Progress in Human Geography*, 16(3), 315-342.

Siegel, A. W. (1981). The externalization of cognitive maps by children and adults: In search of ways to ask better questions. In L. S. Liben, A. H. Patterson, and N. Newcombe (Eds.), *Spatial representation and behavior across the life span: Theory and application* (167-194). New York: Academic Press.

Siegel, A. W., Kirasic, K. C., and Kail, R. V., Jr. (1978). Stalking the elusive cognitive map: The development of children's representations of geographic space. In I. Altman and J. F. Wohlwill (Eds.), *Children and the environment* (223-258). New York: Plenum Press.

Siegel, A. W., and White, S. H. (1975). The development of spatial representations of large-scale environments. In H. W. Reese (Ed.), *Advances in child development and behavior,* Vol. 10 (10-55). San Diego: Academic Press.

Spencer, C., and Blades, M. (1993). Children's understanding of places: The world at hand. *Geography*, 78(4), 367-373.

Spencer, C., Blades, M., and Morsley, K. (1989). *The child in the physical environment: The development of spatial knowledge and cognition.* New York: Wiley.

Thorndyke, P. W. (1981). Spatial cognition and reasoning. In J. H. Harvey (Ed.), *Cognition, social behavior, and the environment* (137-149). Hillsdale, NJ: Lawrence Erlbaum.

Thorndyke, P. W., and Goldin, S. E. (1983). Spatial learning and reasoning skill. In H. L. Pick Jr. and L. P. Acredolo (Eds.), *Spatial orientation: Theory, research, and applications* (195-217). New York: Plenum Press.

Tuan, Y. (1975). Images and mental maps. *Annals of the Association of American Geographers*, 65(2), 205-213.

Verhetsel, A. (1988). In search of a more efficient mental image of the world. In R. Gerber and J. Lidstone (Eds.), *Developing skills in geographical education* Queensland, Australia: International Geographical Union Commission on Geographical Education. (ERIC Document Reproduction Service No. 319644).

Map Learning: Research Studies

Abel, R. R., and Kulhavy, R. W. (1986). Maps, mode of text presentation, and children's prose learning. *American Educational Research Journal*, 23(2), 263-274.

Study examined the effect of three kinds of reference maps on learning from written and aural prose. Learning was greatest from maps with pictorial features directly related to accompanying text, suggesting a mnemonic function for maps. (5th- and 6th-graders)

Amlund, J. T., Gaffney, J., and Kulhavy, R. W. (1985). Map feature content and text recall of good and poor readers. *Journal of Reading Behavior*, 17(4), 317-330.

Experiment 1: below-average readers who studied a map with features represented by mimetic drawings recalled significantly more related text than those who used a map with labels or symbols and labels. Experiment 2: no effect of type of map on text recall for good readers. Results support the conjoint retention hypothesis (dual coding of spatial and verbal information). (5th- and 6th-graders)

Atkins, C. L. (1981). Introducing basic map and globe concepts to young children. *Journal of Geography*, 80(6), 228-233.

Study, follow-up study and replication all showed cognitive gains for subjects who had undergone an instructional program to teach map- and globe-related concepts. (4- and 5-year-olds)

Bayliss, D. G., and Renwick, T. M. (1973). Photograph study in a junior school. In J. Bale, N. Graves, and R. Walford (Eds.), *Perspectives in geographical education* (119-130). Edinburgh, Scotland: Oliver and Boyd.

Study of how children look at pictures with geographic content. (7- and 11-year-olds—British)

Beatty, W. W., and Bruellman, J. A. (1987). Absence of gender differences in memory for map learning. *Bulletin of the Psychonomic Society*, 25(4), 238-239.

Found that males had more accurate knowledge of basic location geography but that there was no difference in acquisition or retention of locations from study of an unfamiliar map. (College students)

Blades, M., and Medlicott, L. (1992). Developmental differences in the ability to give route directions from a map. *Journal of Environmental Psychology*, 12, 175-85.

Assessment of route descriptions from maps on the basis of accuracy and content indicated that those older than ten years had no difficulty. Younger children relied on landmarks and vague direction indicators. (6-, 8-, 10-, 12-year-olds and adults)

Blades, M., and Spencer, C. (1986). Map use by young children. *Geography*, 71(1), 47-52.

Series of studies requiring subjects to use map to locate places in a room, indicate their position on a scale model of a room, walk routes, and navigate through mazes. Indicate children as young as three can use maps. (4- to 6-year-olds)

Blades, M., and Spencer, C. (1987a). The use of maps by 4-6-year-old children in a large-scale maze. *British Journal of Developmental Psychology*, 5, 19-24.

Investigated whether young children could use a map to follow a route in order to navigate a maze. Five- and six-year-olds performed better than chance. (4- to 6-year-olds)

Blades, M., and Spencer, C. (1987b). Young children's recognition of environmental features from aerial photographs and maps. *Environmental Education and Information*, 6(3), 189-198.

Reviews research on young children's successful learning from aerial photographs. Experiment investigating young children's ability to identify symbols on a large-scale map revealed considerable success by the age of six. (4- to 6-year-olds)

Blades, M., and Spencer, C. (1987c). Young children's strategies when using maps with landmarks. *Journal of Environmental Psychology*, 7, 201-217.

When asked to use a map with several examples of the same landmark symbol to locate a path, only subjects older than six were successful. (4- to 8-year-olds)

Blakemore, M. (1981). From way-finding to map-making. *Progress in Human Geography*, 5, 1-24.

Blaut, J. M., McCleary, G. S., Jr., and Blaut, A. S. (1970). Environmental mapping in young children. *Environment and Behavior*, 335-349.

Baseline study of children's ability to identify features from oblique and vertical aerial photographs and to remember content well enough to draw a route from memory. Feature identification was high; the majority successfully completed the route-drawing task. No differences between groups. (1st-graders—American and Puerto Rican)

Bluestein, N., and Acredolo, L. (1979). Developmental changes in map-reading skills. *Child Development*, 50, 691-697.

Investigated the ability of young children to indicate the location of an object in a room from reading maps aligned in various ways. Found that even the youngest subjects succeeded with a map aligned with the room but ability to comprehend a rotated map did not appear until age five. (3- to 5-year-olds)

Bodendorf, F., and Solomon, L. (1978). Cognitive development of spatial concepts. *Geographical Perspectives*, 42(Fall), 29-39.

Study of the developmental differences in ability to interpret an aerial photograph by demonstrating seven map reading skills. Found major developmental transitions after preschool and after third grade. (Preschoolers to 9th-graders)

Carswell, R. J. B. (1971). Children's abilities in topographic map reading. In H. W. Castner and G. McGrath (Eds.), *Map design and the map user* (40-45). (Cartographica, Monograph No. 2). Toronto: York University.

Study of topographic map-reading abilities before and after instruction. Instruction successful for all subjects. Correlations with spatial ability suggest that spatial abilities are "suppressed if not extinguished" as children move through elementary school. (4th- through 6th-graders—Canadian)

Carswell, R. J. B., de Leeuw, A. J., and Early, J. F. (1982). Children's recognition of rural features from anaglyphic representations of vertical aerial photographs. In N. M. Waters (Ed.), *Aspects of human geography: The Kelowna papers, 1981 (B.C. Geographical Series, Number 34; Occasional Papers in Geography)* (75-93). Vancouver, Canada: Tantalus Research Ltd. (ERIC Document Reproduction Service No. ED 232892).

Study 1: Almost all subjects accurately identified relief features from anaglyph. Study 2: Accurate recognitions were greater from an anaglyph than from a two-dimensional aerial photograph of the same scene. (4th- through 6th-graders; 2nd-, 5th- and 8th-graders—Canadian)

Chang, K., Antes, J., and Lenzen, T. (1985). The effect of experience on reading topographic relief information: Analyses of performance and eye movements. *Cartographic Journal*, 22, 88-94.

Experienced topographic map readers used shorter and more numerous eye fixations in studying a topographic map and performed better than inexperienced readers on questionnaire about relative heights. (College students)

Chang, K., and Antes, J. R. (1987). Sex and cultural differences in map reading. *American Cartographer*, 14(1), 29-42.

Analysis of responses to map interpretation questions from reference maps, topographic maps, and a street map showed better performance for males than females and better performance for Taiwanese than Americans. (College students—American and Taiwanese)

Cherry, S. F. (1991). *Action research: Factors influencing recognition of geographical locations on a world map*. ERIC Document Reproduction Service No. ED 343825.

Study of place location knowledge showed negative correlation with exposure to world history and low correlation with exposure to current events news. (High school students)

Cobb, R. L., and Stoltman, J. P. (1973). *Perspective ability and map conceptualization in elementary school children*. Washington, DC: National Council for Geographic Education. (ERIC Document Reproduction Service No. ED 086615).

Results of a test of coordination of perspectives and a test of map conceptualization showed that subjects who have difficulty coordinating perspectives also have difficulty conceptualizing spatial relations of symbols on maps. (Kindergarteners through 6th-graders)

Cooke, K. G. (1978). *The relationship between spatial cognitive developmental levels and the achievement of map skills and concepts*. Doctoral dissertation, State University of New York, Albany.

Study found that complexity of map or map test item, rather than item content affected achievement; that map skill achievement increased as Piagetian spatial skills development increased; and that map skill instruction was only effective for subjects at mid-range cognitive development. (4th-graders)

Cross, K. D. (1982). *Cognitive processes in interpreting the contour-line portrayal of terrain relief.* Santa Barbara, CA: Anacapa Sciences.

Found that experts and novices employ different strategies for determining location from a topographic map. The former focus on macrorelief, reducing the "area of uncertainty," while the latter focus on microrelief. (Adults—Marine Corps infantrymen)

Dale, P. F. (1971). Children's reactions to maps and aerial photographs. *Area*, 3, 170-177.

Investigation of children's recognition of features from a map vs. an aerial photograph showed better performance on the latter and better for familiar areas than unfamiliar. (7- through 11-year-olds—British)

Dean, R. S., and Kulhavy, R. W. (1981). Influence of spatial organization in prose learning. *Journal of Educational Psychology*, 73(1), 57-64.

Experiment 1: Subjects who drew a map while learning a passage exhibited greater retention than those who did not. Experiment 2: Subjects who were forced to study a map while learning a passage retained significantly more than those who were merely instructed to study and those given no map. (College students)

Dow, G. A., and Pick, H. L. (1992). Young children's use of models and photographs as spatial representations. *Cognitive Development*, 7(3), 351-363.

Study comparing very young children's ability to extract information from a scale model vs. a photograph found better performance from the latter if it depicted a familiar area. (2- to 3-year-olds)

Downs, R. M., and Liben, L. S. (1990). Getting a bearing on maps: The role of projective spatial concepts in map understanding by children. *Children's Environments Quarterly*, 7(1), 15-25.

Investigation of link between cartographic and cognitive developmental theory in understanding development of map comprehension. Presents and interprets data from perspective-taking map tasks. (3- to 8-year-olds)

Duhon, J. M. (1970). *The value of simplified maps in selected fifth and sixth grades.* Doctoral dissertation, University of Arizona.

Comparison of simplified and conventional maps for use by children in locating points; estimating size, shape, and distance; determining direction; and making inferences. Conclusions: simplified map preferable for most tasks especially for younger children; no gender differences; inference-making difficult. (5th- and 6th-graders)

Eastman, J. R. (1985). Graphic organization and memory structures for map learning. *Cartographica*, 22(1), 1-20.

Investigation of relation between graphic organization of a map and operations of human memory for spatial data (chunking) via an experiment testing short-term and long-term recall of map information. Found that graphic organization affects nature of chunks but not nature of spatial memory process. (College students)

Fletcher, S. H. (1985, April). *Teachability of map learning strategies.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Study of encoding strategies for interpreting maps (conceptual categories, spatial clusters, spatial movement, mnemonics), which were then taught to other subjects. Concludes that map learning strategies can be successfully taught. (College students)

Frank, R. E. (1987, April). *The emergence of route map reading skills in young children.* Paper presented at the meeting of the Society for Research in Child Development, Baltimore. (ERIC Document Reproduction Service No. ED 288785).

Study of relationship of spatial ability, symbolization, and metacognitive skills to reading of route maps (mimetic or itinerary) and whether those skills can be successfully taught. Results are encouraging. (4- to 6-year-olds)

Frye, M. (1973). *The development of map reading abilities in nine- to fourteen-year-old children.* Doctoral dissertation, Claremont Graduate School.

Study testing Piagetian spatial development theory, found significant developmental transitions between 9- and 10-year-olds and between 10-12-year-olds and 13-14-year-olds. No gender differences.

Gerber, R. (1986). Gifted children and their development of understanding maps. In A. Hernando (Ed.), *Geographical education and society.* (68-89). Sitjes, Spain: International Geographical Union Commission on Geographical Education. (ERIC Document Reproduction Service No. ED 284815).

Case study of two boys over two years, analyzed many assessments of geographical skills, knowledge and ability. (7-8-year-olds—Australian)

Gerber, R. V. (1981). Young children's understanding of the elements of maps. *Teaching Geography,* 6, 128-133.

Study tested children for understanding of verbal definition of map, orthogonal view, arrangement, distance, direction, spatial reference systems, cartographic language, and map-reasoning ability. Findings emphasize difficulty with proportion, scale, and (in younger children) abstract cartographic language. (6- to 8-year-olds—Australian)

Geva, E., and Cohen, R. (1987). *Transfer of spatial concepts from Logo to map-reading.* (ERIC Document Reproduction Service No. ED 288608).

Found that careful implementation of Logo Microworld computer program, involving alternative frames of reference and giving directions involving angles and rotations, can result in transfer of spatial skills to map reading. (2nd- and 4th-graders)

Gilbert, L. C. (1986). *Inducement of metacognitive learning strategies: Task knowledge, instructions, and training.* Paper presented at the 70th Annual Meeting of the American Educational Research Association, San Francisco. (ERIC Document Reproduction Service No. ED 271486).

Results indicated that subjects who were given the most explicit instruction in successful metacognitive strategies in learning features and locations from a map of a small town significantly outperformed other groups on a recall test. (College students)

Gilhooly, K. J., Wood, M., Kinnear, P. R., and Green, C. (1988). Skill in map reading and memory for maps. *Quarterly Journal of Experimental Psychology*, 40(1, Section A), 87-107.

Comparison of memory performance and map-reading strategies of high-skill vs. low-skill map readers with contour maps and planimetric maps found superiority of high-skill readers with contour map but not with planimetric. (College students)

Gilmartin, P. P. (1982). The instructional efficacy of maps in geographic texts. *Journal of Geography*, 81(4), 145-150.

Found that both immediate and delayed recall of information from a text passage were enhanced when a map accompanied the text. No gender difference for the text-plus-map group. (College students—Canadian)

Gilmartin, P. P. (1986). Maps, mental imagery, and gender in the recall of geographical information. *American Cartographer*, 13(4), 335-344.

Comparison of recall of spatial and non-spatial information from text with maps and without maps (subjects instructed to form mental images) found that maps and mental images were equally effective in information recall and that males outperformed females in the text-with-map group. (College students)

Gilmartin, P. P., and Patton, J. C. (1984). Comparing the sexes on spatial abilities: Map-use skills. *Annals of the Association of American Geographers*, 74(4), 605-619.

Five map-use experiments investigate the validity for geography learning of findings by psychologists of male superiority in spatial abilites. Findings were supported for children but refuted for college students. (4th-graders and college students)

Goldberg, J., and Kirman, J. M. (1990). Sex-related differences in learning to interpret Landsat images and in road map reading in young adolescents. *Journal of Geography*, 89(1), 15-25.

Gender differences were explored in interpreting Landsat images, envisioning Landsat areas, road map interpretation, and drawing the route to school. Results indicate significantly higher male performance on Landsat tasks. Concludes that spatial ability correlates too weakly with mapping to generalize for mapping tasks. Questions validity of map-drawing tasks as indicators of mapping ability. (6th- through 8th-graders)

Griffin, T. L. C. (1983). Problem-solving on maps—the importance of user strategies. *Cartographic Journal*, 20(2), 101-109.

Focuses on strategies employed in solving a cartographic problem. Found strong relationship between type of strategy used and performance. Argues for recognition of different strategies by map designers and map-use instructors. (College students—Australian)

Heamon, A. J. (1973/74). The maturation of spatial ability in geography. *Educational Research*, 16, 63-66.

Study to discover developmental stages of skills for generalizating information from and comparability between pairs of maps, pictures, and photographs. Found strong association of performance with age. (8- to 14-year-olds—British)

Hirtle, S. C., and Mascolo, M. F. (1986). Effect of semantic clustering on the memory of spatial locations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 12(2), 182-189.

Three experiments examined the effect of altering labels attached to points on the memory for spatial locations from maps. Found that semantic clustering of labels can produce mental clustering that aids memory for locations. (College students)

Jarest, H. (1991). *Experimental comparison of alternative map scales at an urban middle school.* Doctoral dissertation, University of Massachusetts.

Comparison of effectiveness of several map scales in estimating distances between points. Urges consideration of students' mathematical abilities in designing maps. (7th-graders)

Jones, B. K. (1992). *Place-finding on map projections: An experiment with children*. Doctoral dissertation, Michigan State University.

Subjects were asked to locate points on world maps of different projections after being shown the point on a globe. Perfomance increased with age; no differences among map projections. (2nd-, 4th- and 6th-graders)

Kinnear, P. R., and Wood, M. (1987). Memory for topographic contour maps. *British Journal of Psychology*, 78(3), 395-402.

Investigated how people remember contour maps (information processing) by comparing experimental group that received priming about contours with control group that received priming about distances. After interval, both groups were asked to identify the map they had been studying from five maps. Significantly better performance by experimental group. (13- to 15-year-olds—British)

Kirby, J. R., Jurisich, R., and Moore, P. J. (1984, August). *Effects of map processing upon text comprehension*. Paper presented at the 92nd annual meeting of the American Psychological Association, Toronto. (ERIC Document Reproduction Service No. ED 253859).

Overall recall of details and main ideas from text reading greater for subjects who read the passage and drew a map based on it than for students who read alone. However, map group fared poorer on recall of abstract, non-map-related ideas. (10th-graders—Canadian)

Kirman, J. M. (1981). Use of band 5 black-and-white Landsat images in the elementary grades. *Journal of Geography*, 80, 224-228.

Landsat image interpretation test results at the end of a teaching unit showed that students had significant degree of difficulty interpreting images. Suggests use of images in motivating students. (4th-, 5th- and 6th-graders—Canadian)

Kirman, J. M. (1984). A new elementary level map skill: Landsat 'Band 5' satellite images. *Social Education*, 48, 191-195.

Showed that if the teacher is knowledgeable and students are well instructed, third-graders can interpret selected elements of black-and-white satellite images. (3rd-graders—Canadian)

Kirman, J. M., and Goldberg, J. (1992). Grade six children's perception of a map symbol. *Journal of Geography,* 91(1), 38-40.

Data from study of children's preferences in drawing house symbols on a sketch map reveals that boys orient all houses to top of map while girls orient houses perpendicularly to street. Suggests relation to other gender-based spatial ability differences. (Canadian)

Kirman, J. M., and Jackson, C. (1993). Grade 6 children's ability to use a Landsat digital data computer program. *Journal of Geography,* 92(6), 254-262.

Results show that sixth-graders can derive geographic information from a computer image of Landsat digital imagery after initial training. (Canadian)

Kirman, J. M., and Unsworth, M. (1992). Digital data in the grade 6 classroom. *Journal of Geography,* 91(6), 241-246.

Study of children's understanding of digital data showed that sixth-graders can work with digital data. (Canadian)

Kulhavy, R. W., Lee, J. B., and Caterino, L. C. (1985). Conjoint retention of maps and related discourse. *Contemporary Educational Psychology,* 10(1), 28-37.

Experiment 1: Subjects who wrote a narrative description about a simple reference map remembered more map information than those who wrote a geographic description. Experiment 2: Subjects who viewed a map they had drawn remembered more from listening to a story taking place in that map space than those who did not. (5th-graders)

Kulhavy, R. W., and Schwartz, N. H. (1980). Mimeticism and the spatial context of a map. *Bulletin of the Psychonomic Society,* 15(6), 416-418.

Comparison of recall from maps with or without mimetic drawings showed that presence of drawing increased amount or type of information recalled only at short exposure times. (College students)

Kulhavy, R. W., Schwartz, N. H., and Shaha, S. H. (1982). Interpretative framework and memory for map features. *American Cartographer,* 9(2), 141-147.

Experiment 1: Recall of features from a map with a grid was less but location of features was greater than from a map without a grid. Experiment 2: Subjects recall features from a map in the same sequence in which they saw them. (College students)

Kulhavy, R. W., Shaha, S. H., and Schwartz, N. H. (1983). Spatial representation of maps. *American Journal of Psychology,* 96(3), 337-351.

Experiment 1: Recall of locations from viewing labels-only, labels-plus-mimetic drawings, or labels-plus-geometric symbols maps was greatest when features were semantically congruent with the label referent. Experiment 2: Subjects were able to recognize more interfeature comparisons from a three-quarter reduction than from a full-scale reference map. (College students)

Kulhavy, R. W., Stock, W. A., Peterson, S. E., Pridemore, D. R., and Klein, J. D. (1992). Using maps to retrieve text: A test of conjoint retention. *Contemporary Educational Psychology,* 17(1), 56-70.

In two experiments, subjects who learned a map and text later recalled more text events when cued by the original map than when cued by a reorganized version of the original map. (College students)

Kulhavy, R. W., Stock, W. A., Peterson, S. E., Pridemore, D. R., and Klein, J. D. (in press). Conditions under which maps improve memory for related text. *Contemporary Educational Psychology.*

Kulhavy, R. W., Stock, W. A., Woodard, K. A., and Haygood, R. C. (1993). Comparing elaboration and dual coding theories: The case of maps and text. *American Journal of Psychology,* 106(4), 483-498.

In two experiments, memory for structural properties of the map predicted the recall of text events for subjects who studied a city map then heard a narrative involving the map features. (College students)

Landau, B. (1986). Early map use as an unlearned ability. *Cognition,* 22, 201-223.

Case study of a blind child with no previous map-use experience and control data from sighted children showed that by age four children can use a two-symbol map to guide navigation and locate objects, and can do so when the map is aligned with any cardinal direction. (4-year-olds)

Liben, L. S., and Downs, R. M. (1991, April). *Developing map concepts in children and psychologists: Going beyond maps as representations.* Paper presented at the meeting of the Society for Research in Child Development, Seattle. (ERIC Document Reproduction Service No. ED 333985).

Investigation of the relationship among understanding maps, symbol comprehension, and logical reasoning. Data showed considerable misunderstanding of symbols.

Liben, L. S., and Downs, R. M. (1993). Understanding person-space-map relations: Cartographic and developmental perspectives. *Developmental Psychology,* 29(4), 739-752.

Subjects placed arrow stickers on map of classroom to show location and orientation of adult at various positions in the room, first with map aligned with classroom then with map rotated 180 degrees. Performance was better with aligned map and boys outperformed girls. Results suggest geometric (spatial) rather than representational (symbolic) difficulty in children's use of maps. (5- to 12-year-olds)

Long, M. (1953). Children's reactions to geographical pictures. *Geography,* 38, 100-107.

Interview study found that young viewers of landscape and townscape pictures miss much of their physical geography content and that they exhibit little curiosity about formation of features, even man-made ones. (9- and 10-year-olds—British)

Lowe, R. K. (1993). Constructing a mental representation from an abstract technical diagram. *Learning and Instruction,* 3, 157-179.

Subjects copied a weather map diagram onto a blank country map, then produced a drawn recall weather map. Results showed that meteorologists have superior recall and that they used different information-processing and map-drawing strategies than nonmeteorologists. (Adults—Australian meteorologists and nonmeteorologists)

MacEachren, A. M. (1992). Application of environmental learning theory to spatial knowledge acquisition from maps. *Annals of the Association of American Geographers*, 82(2), 245-274.

Experiment to study spatial knowledge acquisition from maps where segmentation strategies are used to provide a developmental sequence similar to environmental knowledge acquired from behavior in the environment. Found segmentation strategy emphasizing routes made learning easier. Support for dual coding hypothesis. (Male college students)

McAulay, J. D. (1962). Some map abilities of second grade children. *Journal of Geography*, 61(1), 3-9.

Revealed that second-graders can use picture maps of the local area to extract relative distance and direction information, that they can use maps to visualize a different environment, and that they can transfer oral instructions to comparison problems.

McAulay, J. D. (1964). Map learnings in the fourth grade. *Journal of Geography*, 63, 123-127.

Concludes that fourth-graders can acquire map skills integrated into a social studies unit, that maps can help them improve understanding of social studies concepts, and that map learning in school should supplement environmental learning out of school.

McDonald, R. A., and Eliot, J. (1987). Variables contributing to successful aerial photographic interpretation. *Perceptual and Motor Skills*, 64, 551-557.

Found that intelligence and field independence contributed most to performance on two aerial photograph interpretation tests. Gender differences on only one test. (16- to 90-year-olds)

McGee, C. (1982). Children's perception of symbols in maps and aerial photographs. *Geographical Education*, 4, 51-59.

Interview study showed that symbol recognition from topographic maps and aerial and satellite photographs increases with age, the largest change between six and eight years old. (6-, 8-, and 10-year-olds)

McNamara, T. P., Ratcliff, R., and McKoon, G. (1984). The mental representation of knowledge acquired from maps. *Journal of Experimental Psychology*, 10(4), 723-732.

Results of two experiments of recognition priming and distance estimation from maps indicated that psychological distance in cognitive maps depends largely on route distance not Euclidean distance. (College students)

Miller, J. W. (1974). Comparisons of conventional 'subdued' to vivid 'highly contrasting' color schemes for elementary school maps: Report of an experiment. *Journal of Geography*, 41-45.

Results showed greater readability for nonstandard maps for all subject groups. (4th- through 6th-graders)

Miller, J. W. (1982). Improving the design of classroom maps: Experimental comparison of alternative formats. *Journal of Geography*, 52-55.

Subjects' responses to questions requiring interpretation of one of four experimental maps—traditional physical-political, traditional pattern wth limited modifications, two-color locator map, and map with highly-contrasting colors—showed that certain maps are preferable for certain tasks and that certain tasks are more difficult for children. Suggestions for map design included. (4th- through 6th-graders)

Moore, P. J., and Scevak, J. J. (1988, November). *Spatial aids and comprehension: The effects of ability, preference and instruction.* Paper presented at the 38th annual meeting of the National Reading Conference, Tucson. (ERIC Document Reproduction Service No. ED 303786).

Study of effectiveness of training in map use to improve comprehension of text. Investigated effects of individual differences, reading ability, and visual modal preference. (16- and 17-year-olds—Australian)

Murakoshi, S. (1990). Map reading beyond information given: The expert orienteers' internal knowledge about terrain. *Scientific Journal of Orienteering*, 6(1), 10-25.

Comparison of expert and novice orienteers' map interpretation skills showed use of experiential knowledge and internal spatial knowledge representation differences for experts. (Adults)

Neperud, R. W. (1977). The development of children's graphic representations of the large-scale environment. *Journal of Environmental Education*, 8, 57-65.

Analysis of children's sketch maps of the environment supports Piaget's stages of spatial ability development and other previously established sequences of graphic spatial representations. (1st- through 6th-graders)

Ormrod, J. E., Ormrod, R. K., Wagner, E. D., and McCallin, R. C. (1988). Reconceptualizing map learning. *American Journal of Psychology*, 101(3), 425-433.

Comparison of map learning performance of novices and experts using logical and nonlogical maps showed that logical or non-logical spatial organization affected only the experts. Knowledge of principles of spatial organization judged an integral factor in map learning. (College faculty and students)

Perry, M. D., and Wolf, D. P. (1986, May). *Mapping symbolic development.* Paper presented at the 16th annual symposium of the Jean Piaget Society, Philadelphia. (ERIC Document Reproduction Service No. ED 270233).

Subjects made a smaller model from a three-dimensional model of a town, then drew a map of the town. The maps showed a decrease in detail, an increase in accuracy of spatial arrangement and orientation of map symbols, an increased concern for proportion, and a shift in construction perspective to the vertical from the oblique. (Kindergarteners through 2nd-graders)

Presson, C. C. (1982). The development of map-reading skills. *Child Development*, 53, 196-199.

Maps of school were read either inside or outside the space shown, aligned with the space or rotated 90 or 180 degrees. Subjects extracted information from map to guide search to target. Found younger children made egocentric errors with rotated maps and target-to-landmark distance errors. (Kindergarteners and 2nd-graders)

Riding, R. J., and Boardman, D. J. (1983). The relationship between sex and learning style and graphicacy in 14-year-old children. *Educational Review*, 35(1), 69-79.

Analysis of map-reading performance in terms of map-aerial photograph correlation, symbol translation, and view identification. Results indicate performance depends on learning style and sex of subject and the type of map-reading task. (14-year-olds)

Rittschof, K. A., Stock, W. A., Kulhavy, R. W., Verdi, M. P., and Doran, J. M. (1994). Thematic maps improve memory for facts and inferences: A test of the stimulus order hypothesis. *Contemporary Educational Psychology*, 19(2), 129-142.

Subjects studied a map and read a related expository passage. Effects of stimulus order (map-text vs. text-map) were investigated, showing that map-first order resulted in greater recall of text information. (College students)

Rutland, A., Custance, D., and Campbell, R. N. (1993). The ability of three- to four-year-old children to use a map in a large-scale environment. *Journal of Environmental Psychology*, 13, 365-72.

Study extended previous small-scale environment research by asking very young children to use a map to find an object in a large-scale maze. Performance improved significantly with age and depended on the location of the hiding place in the maze.

Saku, J. (1992). Map use teaching and experience. *Cartographica*, 29(3 and 4), 38-45.

Study investigated the effect of instruction in "geographic lexemes" and years of geographic instruction on map use performance. Found strong relationship between instruction/experience and performance on higher level tasks of map interpretation. (College students—Canadian)

Sandford, H. A. (1980). Directed and free search of the school atlas map. *Cartographic Journal*, 17(2), 83-92.

Study confirms usefulness of school atlas in teaching and argues for analysis of free search map learning , especially of scanning, as ways to improve atlas map design. (British)

Satterly, D. J. (1973). Skills and concepts involved in map drawing and map interpretation. In J. Bale, N. Graves, and R. Walford (Eds.), *Perspectives in geographical education* (162-169). Edinburgh, Scotland: Oliver and Boyd.

Analysis of intercorrelations between several psychological variables (conceptual, spatial, perceptual) and mapwork performance tests underscore importance of perception and spatial abilities. (14- and 15-year-olds—British)

Scevak, J. J., and Moore, P. J. (1990). Effective processing of visual information. *Reading*, 24(1), 28-36.

Examination of how students use maps in history and social studies classes. Reports effectiveness of map-comprehension training program. (11th-graders)

Schnotz, W., Picard, E., and Hron, A. (1993). How do successful and unsuccessful learners use texts and graphics? *Learning and Instruction*, 3, 181-199.

Subjects used a time zone map and text on the topic "time and date" to a answer series of questions. Analysis of information processing by the Thinking Aloud Method revealed that successful learners did not retrieve more information but concentrated more on relevant information and adapted better to mental-model construction demands. (College students)

Scholnick, E. K., Fein, G. G., and Campbell, P. F. (1990). Changing predictors of map use in wayfinding. *Developmental Psychology*, 26(2), 188-193.

Study tested predictive strength of element and array rotation and shift from direction perception of an array to recall in effectiveness of map use for wayfinding. (4- to 7-year-olds)

Schwartz, N. H. (1985, April). *Contextual factors in the retention of maps.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Investigated retention of map features and their locations from sixteen experimental maps whose semantic and spatial properties were systematically varied according to familiarity. Results discussed in terms of schema theory and text-map retention research. (College students)

Schwartz, N. H., and Kulhavy, R. W. (1981). Map features and the recall of discourse. *Contemporary Educational Psychology,* 6, 151-158.

Experiment in which subject listened to a narrative accompanied by a map with features located spatially, a map-outline with features listed next to it, or just an outline found recall performance greatest for map group. Ability of subject to reconstruct spatial relations on the map correlated significantly with recall scores. (College students)

Schwartz, N. H., and Phillippe, A. E. (1991). Individual differences in the retention of maps. *Contemporary Educational Psychology,* 16, 171-182.

Study of two procedures for encoding map features by clustering: according to semantic attributes or according to spatial relationship. Interaction effects between encoding style and gender and cognitive style were also explored. (College students)

Shaha, S. H. (1982). *Cognitive processes functional in spatial skills.* Los Angeles: California University Center for the Study of Evaluation. (ERIC Document Reproduction Service No. ED 228271).

Found that field dependence-independence and figural creativity were significant determinants of spatial recall as assessed through a map reconstruction task and that verbal ability was a factor only for the high school students. (High school and college students)

Shepard, R. N., and Hurwitz, S. (1984). Upward direction, mental rotation, and discrimination of left and right turns in maps. *Cognition,* 18, 161-193.

Study argues that the concept of an upward direction has been extended to represent various horizontal directions (e.g., north on a map). Data from two experiments showed that interpretation of turns on a map becomes increasingly difficult as the direction of the line entering the turn departs from upright. (College students)

Shimron, J. (1975). *On learning maps.* La Jolla: California University Center for Human Information Processing. (ERIC Document Reproduction Service No. ED 113706).

Study of responses to questions about a map after studying it and drawing it from memory showed that local relations are learned before large-scale relations, that different types of map information should be presented simultaneously, and that reading a story related to a map is more effective in promoting recall than copying the map. (College students)

Sholl, M. J., and Egeth, H. E. (1982). Cognitive correlates of map-reading ability. *Intelligence,* 6(2), 215-230.

Regression analysis revealed that vocabulary and mathematical aptitude test results were significant predictors of map-reading ability, whereas visual-spatial ability and hemisphericity were not. Suggests importance of verbal-analytic ability to map reading. (College students—ROTC)

Slack, J. P. (1980). *Predicting and improving topographic map skills of college geography students.* Doctoral dissertation, University of Georgia.

Study of demographic and cognitive factors possibly related to topographic map interpretation skills and assessment of the effects of two types of instruction on topographic map skills. (College students)

Snyder, S. S., and Feldman, D. H. (1984). Phases of transition in cognitive development: Evidence from the domain of spatial representation. *Child Development*, 55(3), 981-989.

Reanalysis of data from studying effects of instruction on map-drawing skills in order to explore relationship between reasoning levels and developmental change. (5th-graders)

Somerville, S. C., and Bryant, P. E. (1985). Young children's use of spatial coordinates. *Child Development*, 56, 604-613.

Study of children's ability to extrapolate lines from coordinate markers to locate the correct point from an array of points showed that children may have a stronger grasp of Euclidean spatial relationships than is often suggested. (4- to 6-year-olds)

Spencer, C., Harrison, N., and Darvizeh, Z. (1980). The development of iconic mapping ability in young children. *International Journal of Early Childhood*, 12, 57-64.

A pilot study and a main study investigated the ability of young children to interpret aerial photographs and maps, whether it was related to age and intelligence, and what types of features are most easily recognized. (5- to 11-year-olds and 3- to 4-year-olds—British)

Stasz, C., and Thorndyke, P. W. (1980). *The influence of visual-spatial ability and study procedures on map learning skill. A Rand Note.* Santa Monica, CA: Rand Corporation. (ERIC Document Reproduction Service No. ED 231329).

Study identified six effective map learning procedures—partitioning, imagery, memory-directed sampling, pattern encoding, relation encoding, and evaluation. Found visual spatial ability highly correlated with recall of spatial attributes. High ability subjects benefited more from the use of study procedures than low-ability subjects. (College students)

Stea, D., and Blaut, J. M. (1973). Some preliminary observations on spatial learning in school children. In R. M. Downs and D. Stea (Eds.), *Image and environment: Cognitive mapping and spatial behavior* (226-234). Chicago: Aldine.

First study to determine to what extent young children can interpret aerial photographs of four communities including their own. Results showed success in identifying features; no differences in identification scores for photographs of one's own community vs. others; better success for urban middle-class vs. rural subjects. Second study showed increased identification ability with age, leveling off after fourth grade. (Kindergarteners; 2nd-, 4th- and 6th-graders—Puerto Rico)

Sutherland, S., and Winn, W. (1987, February). *The effect of the number and nature of features and of general ability on the simultaneous and successive processing of maps.* Paper presented at the annual convention of the Association for Educational Communications and Technology, Atlanta. (ERIC Document Reproduction Service No. ED 285560).

Found significant interaction for task (list or draw elements from study of maps) and task by map (number of elements on map). Suggested that number of elements on map is critical if task involves successive processing but that subjects will use a chunking strategy to compensate for numerous elements on a simultaneous processing task. (College students)

Thomas, J. L. (1983, August). *Locational versus featural information in adult visual memory.* Paper presented at the 91st annual convention of the American Psychological Association, Anaheim, CA.

Found age group differences in visual memory of landmarks and locations from map study and a decrease in performance with age. (Adults)

Thorndyke, P. W., and Hayes-Roth, B. (1982). Differences in spatial knowledge acquired from maps and navigation. *Cognitive Psychology,* 14(4), 560-589.

Study provides a link between spatial learning and map learning. Proposes models of spatial knowledge acquisition from maps and navigation. Experiment testing the models showed that map learning is superior for learning location and straight-line distances; navigation is superior for orientation and estimating route distances. (Adults and college students)

Thorndyke, P. W., and Stasz, C. (1980). Individual differences in procedures for knowledge acquisition from maps. *Cognitive Psychology,* 12, 137-175.

Experiment 1: Comparison of experienced and novice map users found that the former use different spatial encoding techniques and have a better understanding of their own learning process. Experiment 2: Evaluated effectiveness of various prescribed procedures derived from Experiment 1. (Adults and college students)

Thorne, K. F. (1991). *Map reading for route selection: Lateral preference, performance and strategies.* Doctoral dissertation, Michigan State University.

Study questioned findings of little relationship between measures of spatial ability and map reading for route selection. Experiment investigated effect of lateral preference on map reading; no relationship found.

Towler, J. (1971). Egocentrism: A key to map-reading ability? *Social Education,* 893-898.

Study of perspective-taking testing Piaget's stages of development. Found subjects are generally in advance of Piaget's stages and that egocentrism weakens earlier. (Kindergarteners through 6th-graders)

Towler, J. O. (1970). The elementary school child's concept of reference systems. *Journal of Geography,* 89-93.

Administered investigator's Test of Four Spatial Concepts, focusing on two tests dealing with rotation of axes and the concept of a natural axes system. Observed four stages in development of reference system; comparison with Piaget. (6- to 11-year-olds—Canadian)

Towler, J. O., and Nelson, L. D. (1968). The elementary school child's concept of scale. *Journal of Geography,* 24-28.

Investigated understanding of scale by having subjects draw a map from a three-dimensional model of a farm, choosing appropriate symbols from a list of different-sized symbols representing different-sized objects in the model. Performance increased with age. Concludes that concept of scale is fully developed by fifth or sixth grade. Comparison with Piaget. (1st- through 6th-graders—Canadian)

Underwood, J. D. M. (1981). Skilled map interpretation and visual-spatial ability. *Journal of Geography*, 55-58.

Found strong relationship between visual-spatial ability and map-reading skills for less-experienced (in geography) subjects, no relationship for more experienced subjects. (15- and 17-year-old girls—British)

Uttal, D. H., and Wellman, H. M. (1989). Young children's representations of spatial information acquired from maps. *Developmental Psychology*, 25(1), 128-138.

Two experiments showed that all older subjects and many younger ones could learn the layout of a large playhouse by memorizing a map, and that map memorization facilitated route learning and navigation. Suggests preschoolers are more capable than previously thought. (4- to 7-year-olds)

Van der Schee, J., van Dijk, H., and van Westrhenen, H. (1992). Geographical procedural knowledge and map skills. In H. Schrettenbrunner and J. van Westrhenen (Eds.), *Empirical research and geography teaching*. Amsterdam, Netherlands: Center for Geographic Education, Royal Dutch Geographical Society. (ERIC Document Reproduction Service No. ED 361236).

Study combining qualitative and quantitative measures found that students are object-oriented and do not think in spatial or areal patterns. Consequently they have difficulty applying procedural knowledge (as opposed to declarative knowledge). (7th through 10th-graders—Dutch)

Walker, R. J. (1980). Map using abilities of 5- to 9-year-old children. *Geographical Education*, 3, 545-554.

Success of children in combining several map skills to solve a map-using problem suggests map understanding appears quite early. (British)

Wilson, P. (1981). The map reasoning development of eight-, ten- and twelve-year-old pupils as revealed in free recall sketch maps. In P. Wilson, R. Gerber, and J. Fien (Eds.), *Research in geographical education* (143-199). Brisbane, Australia: Australian Geographical Educational Research Association. (ERIC Document Reproduction Service No. ED 206554).

Study related map drawing abilities from free recall sketch maps of two familiar areas to ten demographic variables. Found a positive relationship with verbal and non-verbal intelligence and reading age; no relationship with age or sex. Concludes that sketch maps are valid for identifying and predicting map reasoning development. (Australian)

Wilson, P. S. (1980). *The map reasoning development of pupils in years three, five and seven as revealed in free recall sketch maps*. Doctoral dissertation, The Ohio State University.

Study based on Piaget found that intelligence (verbal and non-verbal), reading age, and map skills scores predicted sketch map accuracy whereas socioeconomic status, sex, and age (within year levels) did not. Proportion was found to be the most difficult map element to work with. (3rd-, 5th-, and 7th-graders)

Winn, W. D., and Sutherland, S. W. (1989). Factors influencing the recall of elements in maps and diagrams and the strategies used to encode them. *Journal of Educational Psychology,* 81(1), 33-39.

Examined familiarity and number of elements in maps and diagrams, the way they were represented (labeled drawing or squares), and subjects' ability as factors in subjects' performance in recalling features or locations from study of maps and diagrams. Drawings were remembered better than squares for low-ability subjects; no difference for high ability. High-ability subjects used different study strategies. (High school students)

Wulf, V. J. (1978). *The relation between measures of spatial ability and map understanding.* Master's thesis, University of Wisconsin, Madison.

Found strong relationship between spatial ability scores and map understanding test scores. Higher map reading scores for males. (College students)

Map Learning: Reviews of Research

Balchin, W. G. V. (1976). Graphicacy. *American Cartographer,* 3(1), 33-38.

Blades, M., and Spencer, C. (1986). Map use in the environment and educating children to use maps. *Environmental Education and Information,* 5(4), 187-204.

Blaut, J. M., and Stea, D. (1973). Studies in geographic learning. In J. Bale, N. Graves, and R. Walford (Eds.), *Perspectives in geographical education* (87-100). Edinburgh, Scotland: Oliver and Boyd.

Boardman, D. (1989). The development of graphicacy: Children's understanding of maps. *Journal of Geography,* 74(4), 321-331.

Boardman, D. (1990). Graphicacy revisited: Mapping abilities and gender differences. *Educational Review,* 42(1), 57-64.

Brewster, S., and Blades, M. (1989). Which way to go? Children's ability to give directions in the environment and from maps. *Environmental Education and Information,* 8(3), 141-156.

Catling, S. (1983). The development of children's map ability. In J. Fien, R. Gerber, K. Laws, and P. Wilson (Eds.), *Research in geographical education—Volume 2. Papers presented to the 2nd National Meeting of the Australian Geographical Research Association (Sydney, Australia, December 4-6, 1982)* (3-22). Brisbane, Australia: Australian Geographical Educational Research Association. (ERIC Document Reproduction Service No. ED 250220).

Catling, S. J. (1979). Maps and cognitive maps: The young child's perception. *Geography,* 64, 288-296.

Downs, R., and Liben, L. (1988). Through a map darkly: Understanding maps as representations. *The Genetic Epistemologist,* 16(1), 11-18.

Downs, R. M., and Liben, L. S. (1987). Children's understanding of maps. In P. Ellen and C. Thinus-Blanc (Eds.), *Cognitive processes and spatial orientation in animal and man* (202-219). Dordrecht, Germany: Martinus Nijhoff.

Gerber, R. (1981). Children's development of competence and performance in cartographic language. In P. Wilson, R. Gerber, and J. Fien (Eds.), *Research in geographical education* (98-124). Brisbane, Australia: Australian Geographical Educational Research Association. (ERIC Document Reproduction Service No. ED 206554).

Giffard, E. O. (1972). *Cartographic symbolism and very young children*. (ERIC Document Reproduction Service No. ED 062238).

Golledge, R. G. (1991). Tactual strip maps as navigational aids. *Journal of Visual Impairment and Blindness*, 85(7), 296-301.

Hampson, P. J., and Daly, C. M. (1989). Individual variation in tactile map reading skills: Some guidelines for research. *Journal of Visual Impairment and Blindness*, 83(10), 505-509.

Kirby, J. R. (1993). Collaborative and competitive effects of verbal and spatial processes. *Learning and Instruction*, 3, 201-214.

Kirby, J. R., and Schofield, N. J. (1991). Spatial cognition: The case of map comprehension. In G. Evans (Ed.), *Learning and teaching cognitive skills* (107-123). Hawthorn, Victoria, Australia: Australian Council for Educational Research.

Liben, L. S., and Downs, R. M. (1986). *Children's production and comprehension of maps: Increasing graphic literacy* (Final report to the National Institutes of Education No. NIE G-83-0025).

Liben, L. S., and Downs, R. M. (1989). Understanding maps as symbols: The development of map concepts in children. In H. W. Reese (Ed.), *Advances in child development and behavior*, Vol. 22 (145-201). San Diego: Academic Press.

Matthews, M. H. (1986). Children as map makers. *Geographical Magazine*, March, 124-129.

Mayer, R. E. (1993). Commentary. Comprehension of graphics in texts: An overview. *Learning and Instruction*, 3, 239-245.

Milburn, D. (1980). Mapping in the early years of schooling. In R. Choquette, J. Wolforth, and M. Villemure (Eds.), *Canadian geographical education* (71-87). Ottawa: University of Ottawa Press/Canadian Association of Geographers.

Moore, P. J. (1993). Metacognitive processing of diagrams, maps and graphs. *Learning and Instruction*, 3, 215-226.

Muir, S. P. (1985). Understanding and improving students' map reading skills. *Elementary School Journal*, 86(2), 207-216.

Olson, J. M. (1984). Cognitive issues in map use. *International Yearbook of Cartography, 24,* 151-157.

Rushdoony, H. A. (1968). A child's ability to read maps: Summary of the research. *Journal of Geography,* 67(4), 213-222.

Rushdoony, H. A. (1971). The geographer, the teacher, and a child's perception of maps and mapping. *Journal of Geography,* 70(7), 429-433.

Schwartz, N. H., and Kulhavy, R. W. (1984, April). *Cognitive processing characteristics and the instructional utility of maps.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Slater, F. A., and Spicer, B. (1982). Studying relationships and building models through the analysis of maps and photographic evidence. In N. J. Graves (Ed.), *New UNESCO source book for geography teaching* (206-254). Paris: UNESCO.

Winn, W. (1991). Learning from maps and diagrams. *Educational Psychology Review,* 3(3), 211-247.

Formal Geography Learning: Research Studies

Alharthi, D. D. (1990). *The effects of programmed instruction in teaching geography to low achievers in the intermediate schools of Saudi Arabia.* Doctoral dissertation, University of South Florida.

Found that programmed instruction improves performance of low achievers in goegraphy and that attitudes toward programmed instruction were positive.

Anderson, J. M. (1987). *The relation of instruction, verbal ability, and sex to the acquisition of selected cartographic skills in kindergarten children.* Doctoral dissertation, University of Wisconsin.

Found that instruction (map construction vs. field use) and verbal ability were significant factors in learning to read maps, but that interactions occurred among particular map skills, instruction, and subject characteristics. (Kindergarteners)

Anderson, R. T. (1983). *The effect of varying teaching strategies on geographic concept attainment and learning skills development in college freshmen.* Doctoral dissertation, Boston University.

Concluded that teaching strategy (expository/lecture vs. inquiry/discovery-based) produced no difference in attainment or retention of the concept of spatial diffusion. (College students)

Audet, R. H. (1993). *Developing a theoretical basis for introducing geographic information systems into high schools: Cognitive implications.* Doctoral dissertation, Boston University.

Investigated behaviors of experts and novices when interacting with a GIS program (ArcView). Found three problem-solving styles.

Barbetta, P. M., and Heward, W. L. (1993). Effects of active student response during error correction on the acquisition and maintenance of geography facts by elementary students with learning disabilities. *Journal of Behavioral Education*, 3(3), 217-233.

Small sample size. Findings support value of active student response in learning basic geography facts (state capitals) for this population. (10- and 11-year-olds)

Baum, E. A. (1978). Shapes and sounds as self-objects in learning geography. *Child Psychiatry and Human Development*, 8(4), 229-238.

Observation study of six subjects showed creative associations of geography facts and personal interests (e.g., pet names) by four subjects. (6-year-old girls)

Beatty, W. W., and Tröster, A. I. (1987). Gender differences in geographical knowledge. *Sex Roles*, 16(11/12), 565-590.

Proposes an attentional hypothesis to account for males' superior performance on test of place location knowledge acquisition from map study. Suggests difference may be caused by the fact that women have less active control over travel in their lives. (College students)

Beck, I. L., McKeown, M. G., and Gromoli, E. W. (1989). Learning from social studies texts. *Cognition and Instruction*, 6(2), 99-158.

Content analysis of a 4th-grade geography text sequence and a 5th-grade history sequence. Problems in the topic sequences include unclear content goals, assumed background knowledge, and inadequate explanations.

Bednarz, S. W. (1992). *The effect of mnemonics and attention-enhancing techniques on learning place geography*. Doctoral dissertation, Texas AandM University.

Found that use of keyword mnemonic devices, especially in combination with the attention-enhancing device of repeated test-like practice (and to a lesser extent cooperative learning) significantly improve place location learning. (6th- and 9th-10th-graders)

Beilin, L. A. (1970). *An analytic-empirical study of sequence in curriculum development*. Doctoral dissertation, Columbia University.

Investigated the relationship of map skills to spatial concepts and map skills and spatial concepts sequencing in curricula vis-à-vis Piaget's stages of development. Found strong relationship and later development of spatial concepts than indicated by Piaget. (Kindergarteners, 2nd- and 5th-graders)

Bein, F. L. (1988). *Impact of travel on geographic competency*. Paper presented at the annual meeting of the National Council for Geographic Education, Snowbird, UT. (ERIC Document Reproduction Service No. ED 310052).

Found a strong correlation between travel and geographic skill and knowledge in map skills, place name location, physical geography, and human geography. (College students)

Beishuizen, J. J. (1992). Studying a complex knowledge domain by exploration or explanation. *Journal of Computer-Assisted Learning*, 8(2), 104-117.

Two experiments investigated the educational value in geography teaching of a computer simulation program modelling effects of erosion on agriculture. (High school students)

Ben-Chaim, D., Lappan, G., and Houang, R. T. (1988). The effect of instruction on spatial visualization skills of middle school boys and girls. *American Educational Research Journal*, 25(1), 51-71.

Found that subjects at all levels gained from instruction involving concrete activities such as building and drawing solids made of cubes. (5th- through 8th-graders)

Bolding, R. A. (1992). *A study to determine the effect of literature in enhancing geographic knowledge in secondary school students.* Doctoral dissertation, Memphis State University.

Results showed that integration of geography concepts into literature units can enhance learning in both subjects. (8th-graders)

Bramwell, J. (1987). Pupils' attitudes towards geography in the lower school: An investigation into gender differences. *Geography*, 72(1), 36-48.

Discovered significant gender differences in frequency with which learning difficulties were experienced and in preferences for particular learning activities and topics. (4th-graders—British)

Brigham, F. J. (1993, April). *Places, spaces and memory traces: Showing students with learning disabilities ways to remember locations and events on maps.* Paper presented at the 71st annual conference of the Council for Exceptional Children, San Antonio. (ERIC Document Reproduction Service No. EC 302101).

Findings indicated that recall of location is significantly enhanced by use of keyword mnemonic devices, that mnemonics did not enhance recall of events, and that locations were more frequently recalled than events. (Middle school students)

Brown, M. H. (1990). *The geographic information system in a junior high school environment.* Doctoral dissertation, University of Manitoba.

Results showed that computerized GIS programs can enhance geography learning for students of different academic performance levels. (7th-graders)

Bruno, E. M. J. (1989). *Map literacy: Designing an instructional videotape to teach map-reading skills to high school students.* Doctoral dissertation, Columbia University Teachers college.

Field test data support the assertion that the teacher-prepared video can serve as an effective instructional medium, increasing student learning and improving student attitudes toward map reading.

Butler, P. D. (1990). *A study utilizing a Type I incidental learning paradigm to increase place name and location literacy in elementary age subjects.* Doctoral dissertation, Memphis State University.

Comparison with the direct instruction teaching method showed that the Type I incidental learning paradigm was more effective (though not significantly so) in teaching place location. (Elementary students)

Carmichael, D. R. (1965). *Developing map reading skills and geographic understanding by means of conceptual teaching methods.* Doctoral dissertation, University of California at Berkeley.

Found that students taught by conceptual teaching methods (vs. expository methods) showed significantly greater achievement in geographic understandings, greater (short of significance) achievement in map-reading skills, and were more highly motivated and self-directed. (Elementary school students)

Chang, S.-J. (1987). *An application of schema theory to school learning: Learning geography with the help of a notetaking schema (China).* Doctoral dissertation, University of Texas at Austin.

Investigation of students' notetaking found that a notetaking schema can positively affect students' encoding and recall of geographic information. (8th-graders—Taiwanese)

Chapman, L. (1991). *Use of computers in the high school social studies classroom.* Doctoral dissertation, University of Alberta.

Case study of computer database and simulation use in teaching economic geography found increased student learning and positive attitudes. (16- and 17-year-olds—Canadian)

Cherry, S. F. (1991). *Action research: Factors influencing recognition of geographical locations on a world map.* (ERIC Document Reproduction Service No. ED 343825).

Study of the relationship of various factors and geographical knowledge found a negative correlation between knowledge and exposure to world history instruction and current events news exposure. (High school students)

Chevrette, P. A. (1987). *A comparison of college students' performances with alternate simulation formats under cooperative or individualistic class structures.* Doctoral dissertation, Texas A&M University.

Study of learning from an urban geography simulation game under four conditions: simulation on computer, students working in pairs; computer simulation, students working individually; paper and pencil simulation, pairs; paper and pencil, individual. ANOVA showed signficant gains for pair learning and greatest gains for the paired paper and pencil condition. Subjects preferred computer and pair conditions.

Chiappetta, E. L., and Russell, J. M. (1982). The relationship among logical thinking, problem solving instruction, and knowledge and application of Earth science subject matter. *Science Education*, 66(1), 85-93.

Found that logical thinking accounted for more variation in achievement than type of instruction. (8th-graders)

Collins, A., Adams, M. J., and Pew, R. W. (1978). Effectiveness of an interactive map display in tutoring geography. *Journal of Educational Psychology*, 70(1), 1-7.

Study and replication of learning from a computer-assisted instructional system accompanied by an interactive map display, a static labeled map, or an unlabeled map. Showed significantly greater learning with the interactive map. (High school students; college students)

Cross, J. A. (1987). Factors associated with students' place location knowledge. *Journal of Geography*, 86(2), 59-63.

Results showed that knowledge of current events had a strong effect on place location knowledge whereas previous geography coursework had none. (College students)

Cummings, C. S. (1992). *Using curriculum-based assessment to increase rates of geography skill acquisition in secondary level students with learning disabilities.* Doctoral dissertation, Johns Hopkins University.

Found that curriculum-based assessment increased student skill achievement rates in locating countries on a blank map and matching names of countries with their capital cities. Small sample size. (12- to 14-year-olds)

Flatt, C. A. L. (1985). *The effect on learning of geographic instruction designed for students' verbal and spatial abilities.* Doctoral dissertation, University of North Texas.

Found that instruction directed to students' verbal and spatial abilities had no significant effect on performance compared to traditional instruction. Teaching via textbook and whole-group instruction resulted in larger learning gains than teaching with materials directed toward different learning styles and abilities. (High school students)

Forsyth, A. S., Jr. (1986). *A computer adventure game and place location learning: Effects of map type and player gender.* Doctoral dissertation, Utah State University.

Found that subjects retained spatial location information from a simulated-travel computer game better with an accompanying labeled (or label-plus-drawings) map. No gender differences found. Follow-up showed long-term retention. (4th- and 5th-graders)

Francek, M. A., Nelson, B. D., Aron, R. H., and Bisard, W. J. (1993). The persistence of selected geographic misperceptions: A survey of junior high through undergraduate college students. *Journal of Geography*, 92(6), 247-253.

Assessment of the degree to which subjects misperceive relative locations of continents, states, and ocean sizes revealed that misperceptions persist but decrease in frequency across all educational levels, and that gender difference favoring males decreased with age.

Freitag, P. M., and Abegg, G. L. (1991, April). *Learning in the middle school Earth science classroom: Students conceptually integrate new knowledge using intelligent laserdiscs.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Lake Geneva, WI. (ERIC Document Reproduction Service No. ED 336262).

Study investigated student planning and production of informative interactive laserdisc programs on the topic of weather for their peers.

French, R. L., Schmudde, T. H., and Bobbett, G. C. (1989, November). *A study of learning style accommodation and thinking skills instruction found in the teaching of thematic map use.* Paper presented at the annual meeting of the Mid-South Educational Research Association, Little Rock, AR. (ERIC Document Reproduction Service No. ED 313450).

Content analysis of teaching activities and instructional materials related to thematic map use for evidence of learning style accommodation and thinking skills instruction, conducted at a summer institute for geography teachers (Tennessee Geographic Alliance/National Geographic Society). Found that, in general, activities and materials accommodated learning styles and promoted higher-order thinking skills. (4th- through 12th-grade teachers)

Gerber, R. (1992). Technology education: An emerging component in geographical education? In A. D. Hill (Ed.), *International perspectives on geographic education* (283-298). Boulder: University of Colorado Center for Geographic Education.

Survey of international geography educators assessed their understanding of the concept of technology, attitudes toward technology, knowledge and ability to use different technologies, access to and use of technology in their teaching, and perceived effects of technology on their teaching. Includes data in the form of respondents' drawings and diagrams. Presents baseline for future technology education of geography educators.

Gilmartin, P. P. (1982). The instructional efficacy of maps in geographic texts. *Journal of Geography*, 81(4), 145-150.

Found that both immediate and delayed recall of information from a text passage were enhanced when a map accompanied the text. No gender difference for the text-plus-map group. (College students—Canadian)

Glowatski, E. A. (1973). Behavioral objectives for geography facilitate communication and increase test performance. *Journal of Geography*, 72(7), 36-45.

Results indicated that use of daily behavioral objectives as an integral component of geography instruction facilitates increased test achievement. (College students)

Gregg, M., and Leinhardt, G. (1993). Geography in history: What is the where? *Journal of Geography*, 92(2), 56-63.

Geography content analysis of secondary school U.S. and European Advanced Placement history lessons found that 75% of references to geographic content were "passing references," not "substantive references." (High school)

Gregg, M., and Leinhardt, G. (1994). *Constructing geography*. Pittsburgh: University of Pittsburgh Learning Research and Development Center.

Naturalistic study of conservative constructionist and traditional didactic map-reading and map-interpretation lessons found that active map-makers learned more than passive map-readers, especially among low-knowledge students. (7th-graders)

Gregg, M., Stainton, C., and Leinhardt, G. (1990). *Where is geography? Three studies of thinking and teaching* (Technical Report No. CLIP-90-04). Pittsburgh: Learning Research and Development Center, University of Pittsburgh. (ERIC Document Reproduction Service No. ED 337393).

Data from an analysis of geographic references in *The New York Times* was "aligned" with a content analysis of elementary textbooks and a survey of elementary teachers' goal statements to reveal gaps in education for geographic literacy and to yield recommendations for geography curriculum design. (Elementary)

Grieve, T. D., and Davis, J. K. (1971). The relationship of cognitive style and method of instruction to performance in ninth grade geography. *Journal of Educational Research*, 65(3), 137-141.

Investigation of two methods of instruction (discovery and expository) and two cognitive styles (analytic and global) for their effect on lower-order and higher-order geography learning. Found no significant main effects or interactions, but several second-order interactions. (9th-graders)

Griffin, M. M. (1992). *A comparison of situated cognition and traditional instruction in teaching map skills*. Doctoral dissertation, Florida State University.

Results showed that the situated cognition group performed significantly better than the traditional instruction group on a map skills performance test. (4th-graders)

Haigh, M. J. (1986). The evaluation of an experiment in physical geography teaching. *Journal of Geography in Higher Education*, 10(2), 133-147.

Assessed the effects of organizing a physical geography course according to the General Theory of Systems to encourage students to think more holistically about the environment. Enhanced learning for more committed, achievement-oriented students; negatively affected learning for students with nonacademic orientation and poor study habits. (College students)

Herman, W. L., Hawkins, M. L., Barron, M., and Berryman, C. (1988). World place location skills of elementary school students. *Journal of Educational Research*, 81(6), 374-376.

Found that place location knowledge varied with subject's socioeconomic status and mobility, in addition to age and gender. (4th- through 6th-graders)

Kaplan, R. G. (1990, May). *The role of mathematical knowledge in children's understanding of geographical concepts.* Paper presented at the annual meeting of the New England Educational Research Organization, Rockport, ME. (ERIC Document Reproduction Service No. ED 324205).

Results indicated a positive relationship between overall mathematics performance and overall geography performance. However, subjects with lower mathematics performance had lower scores on some but not all of the geography measures, hinting at the influence of a common, nonmathematical factor. (3rd- through 6th-graders)

Khan, A. A. (1983). *A comparison of the conventional lecture method of instruction with programmed instruction and the lecture-laboratory approach in teaching introductory physical geography at the university level.* Doctoral dissertation, Catholic University of America.

Found that the conventional lecture method was the most successful, that the lecture-laboratory method was successful for a heterogeneous class with regard to achievement levels and learning styles, and that programmed instruction can be used effectively with the lecture method for overlearning.

Khan, S. (1984). *Geographic place location knowledge: An empirical investigation into the performance of university undergraduate students as a result of cognitive theory based instruction.* Doctoral dissertation, Western Michigan University.

Found that cognitive theory-based exercises and instructional materials do enhance place location knowledge at this level.

Knapczyk, D. (1991). Effects of modeling in promoting generalization of student question asking and question answering. *Learning Disabilities Research and Practice*, 6(2), 75-82.

Study of three learning disabled students in which videotaped segments from a world geography textbook were used to provide modeling, rehearsal, and directed feedback in question asking and answering. Results indicated that the training procedures were effective in improving the generalization of target skills. Follow-up showed long-term retention of question asking and answering skills. (9th-graders—learning disabled)

Kon, J. H., and Martin-Kniep, G. O. (1992). Students' geographic knowledge and skills in different kinds of tests: Multiple-choice versus performance assessment. *Social Education*, 56(2), 95-98.

Results of a case study indicate that performance test administration and scoring were no more complicated than for traditional testing.

Kulhavy, R. W., Schwartz, N. H., and Koroscik, J. (1983). Topic relations in map-based instruction. *Educational and Psychological Research*, 3(4), 235-242.

Factor analysis study to determine how teachers view map-related topics in terms of importance in classroom instruction yielded five prominent factors: context (e.g., interpreting relief, locating boundaries), structure (e.g., symbols, scale, legends), function direction and orientation, location learning), Earth relations and itinerary construction (navigation actitivies).

Lahnston, A. T. (1972). *A comparison of directed discovery and demonstration strategies for teaching geographic concepts and generalizations*. Doctoral dissertation, University of Washington.

Results showed that subjects taught by demonstration strategies scored significantly higher on the immediate retention measure than those taught by the directed discovery strategy. There was no difference found for measures of delayed retention, immediate or delayed transfer. (3rd-graders)

Lazer, S. (1992). *Learning about the world*. Princeton, NJ: Educational Testing Service Center for the Assessment of Educational Progress. (ERIC Document Reproduction Service No. ED 350354).

Large survey study (N=3300) of geography knowledge in three areas (skills and tools, physical geography, cultural geography) using the optional geography component of the International Assessment of Educational Progress. Found positive relationship between scores and books in home, family size, and leisure reading. Students performed best on map and chart reading. (13-year-olds—many nations)

Lee, C. K. (1992). *General reasoning ability and domain-specific knowledge in students' ability to solve problems in geography*. Doctoral dissertation, Columbia University Teachers College.

Found that both general reasoning ability and domain-specific knowledge were significant in affecting students' ability to solve decision-making problems in geography. Peformance was higher for gifted than for non-gifted students. No gender difference was found. Revealed inadequate problem-solving strategies, in general. (High school students)

Levin, S. R. (1991). The effects of interactive video enhanced earthquake lessons on achievement of seventh grade earth science students. *Journal of Computer-Based Instruction*, 18(4), 125-129.

Study examined effects of interactive video vs. traditional text instructional methods, in computer lab and classroom settings, on boys and girls.

Mackenzie, A. A., and White, R. T. (1982). Fieldwork in geography and long-term memory structures. *American Educational Research Journal*, 19(4), 623-632.

Examined effects of three treatments (active excursion, passive excursion, no excursion) on learning and retention of geographical facts and skills from fieldwork. Found that excursion treatments were more successful than no excursion for initial learning and that active excursion was superior for retention. (8th- and 9th-graders)

Maddalena, N. C. (1991). *Linking writing to reading: The effect of thematic instruction in geography on retention and writing quality*. Doctoral dissertation, University of Oregon.

Study in which subjects received instruction in writing to reinforce textbook learning. Showed significantly more idea units in post-treatment writing samples for experimental group and greater retention but no increase in writing skills. (10th-graders)

Mastropieri, M. A., and Scruggs, T. E. (1983). Maps as schema for gifted learners. *Roeper Review*, 6(2), 107-111.

Two studies compared effect on recall of information from hearing a prose passage preceded or followed by study of a spatially organized map or a list map. Results indicated that the spatially organized map was superior to the list map regardless of when it was presented, and that subjects in prior presentation conditions and subjects using a spatially organized map scored significantly better than those in other conditions. (Junior high school)

Mastropieri, M. A., and Scruggs, T. E. (1989). Mnemonic social studies instruction: Classroom applications. *Remedial and Special Education*, 10(3), 40-46.

Found that immediate and delayed post-treatment scores were significantly higher for subjects receiving mnemonic-based instruction than for those receiving traditional instruction. (Elementary school students—mildly handicapped)

Mastropieri, M. A., Scruggs, T. E., and Bakken, J. P. (1992). A complex mnemonic strategy for teaching states and their capitals: Comparing forward and backward associations. *Learning Disabilites Research and Practice*, 7(2), 96-103.

Results indicated that subjects scored higher on items taught mnemonically than on items taught traditionally, regardless of whether the items required forward or backward association. Found significant correlations between performance and particular mnemonic strategy used. (Junior high school students—learning-disabled)

McGhee, L. E. (1991). *Influence of race, gender, travel, geography courses, and geography content in other courses upon geographic literacy of high school students*. Doctoral dissertation, Memphis State University.

Regression analysis indicated that gender, race, and travel were significant predictors of geographic literacy as measured by a geography-based competency test. Males and Caucasians were found to have greater knowledge of geographic concepts than females and Blacks.

McKenzie, G. R., and Sawyer, J. (1986). Effects of test-like practice and mnemonics on learning geographic facts. *Theory and Research in Social Education*, 14(3), 201-209.

Study found that instruction using mnemonics was more effective than traditional lecture (i.e., listen/discriminate) method and that the combination of mnemonics and test-like practice was particularly effective in enhancing learning of place location. (5th-graders—50 percent Black)

Metallinos, N., Muffoletto, R., Pettersson, R., Shaw, J., and Takakuwa, Y. (1990, July). *The use of verbo-visual information in textbooks: A cross-cultural experience*. Paper presented at the International Visual Literacy Symposium, London. (ERIC Document Reproduction Service No. ED 325819).

Content analysis of secondary geography textbooks from Australia, Greece, Japan, Sweden, and the U.S., focusing on verbo-visual content. Found that American textbooks were the largest but had the least information, few maps, and an average number and size of pictures.

Moore, P. J., and Kirby, J. R. (1985, May). *The effects of spatial organizers on text comprehension.* Paper presented at the 30th annual meeting of the International Reading Association, New Orleans. (ERIC Document Reproduction Service No. ED 264530).

Study examined the effects of presence vs. absence of reader-generated map-like representations (spatial organizers) on subjects' delayed recall of a narrative passage. Results indicated that low ability students were negatively affected by map construction while the performance of high ability students was enhanced. (College students)

Nolet, V. W. (1992). *A comparison of two approaches to teaching world geography to facilitate complex thinking.* Doctoral dissertation, University of Oregon.

Study investigating effects on learning geography facts and problem solving of topical instruction vs. relationship instruction found no difference regarding factual learning and greater ability of the relationships instruction group to juxtapose concepts and principles. (10th-graders)

Nussbaum, J., and Sharoni-Dagan, N. (1983). Changes in second grade children's preconceptions about the Earth as a cosmic body resulting from a short series of audio-tutorial lessons. *Science Education,* 67(1), 99-114.

Study of learning concepts via the "reception learning" model found that children receiving the audio-tutorial instruction attained a concept development level more advanced than the relevant concept development of older children instructed by conventional means.

Pelletti, J. C. (1973). *The effects of graphic roles on learning geography materials in the middle grades.* Doctoral dissertation, University of Georgia.

Pettersson, R., Metallinos, N., Muffoletto, R., Shaw, J., and Takakuwa, Y. (1991, October). *The use of verbo-visual information in the teaching of geography.* Paper presented at the 23rd annual meeting of the International Visual Literacy Association, Washington. (ERIC Document Reproduction Service No. ED 342047).

Study investigated use of media and pictures in teaching geography by teachers in five countries (Australia, Greece, Japan, Sweden, and the U.S.). Results revealed that there was great variation in use of media by individual teachers, that chalkboard and textbook are the predominant media, that wall maps are used weekly in the U.S. (less frequently than in Japan), and that print media was used far more than audio-visual media.

Purnell, K. N., and Solman, R. T. (1991). The influence of technical illustrations on students' comprehension in geography. *Reading Research Quarterly,* 26(3), 277-299.

Results of five experiments showed that technical content that lends itself to presentation as an illustration will be comprehended better as an illustration than as text, and best when presented in both forms. (9th- through 12th-graders—Australian)

Rand, D. C. (1973). *The relationship between children's classification-class inclusion abilities and geographic knowledge as measured by Piaget's spatial stages.* Doctoral dissertation, Purdue University.

Results indicated that children's classification-class inclusion abilities are not related to geographic knowledge, but that gender (boys outscored girls), community (urban outperformed rural), and socioeconomic status (higher outperformed lower), and age are significant factors. (Elementary school students)

Saku, J. C. (1990). *The impact of teaching cartographic lexicon and of geographic experience on map use.* Doctoral dissertation, Wilfred Laurier University.

Study investigates the teaching of cartography as a second language, with its own lexicon and syntax. (College students—Canadian)

Satanek, M. C. (1971). *An application of selected Piagetian spatial tests to geographic education.* Doctoral dissertation, Case Western Reserve University.

An investigation of the relationship between spatial abilities (as measured by Piagetian tasks) and geography knowledge showed a significant positive correlation, with no significant gender differences. (4th-graders)

Savage, T. V., Jr., and Bacon, P. (1969). Teaching symbolic map skills with primary grade children. *Journal of Geography,* 68(8), 491-497.

An experiment comparing two methods of teaching map symbols (manipulating concrete objects vs. abstract level instruction) found no significant difference between treatments. Subjects evinced no difficulty learning from abstract level instruction. (1st-graders)

Saveland, R. N. (1983). Map skills around the world: How to test and diagnose place vocabulary capabilities. *Social Education,* 47(3), 206-211.

Reports results of a very large survey (N=12,500) of place location knowledge of students from 13 countries, using The World Basic Place Vocabulary Test. Students from developed countries scored higher than students from developing countries. Boys scored higher than girls. (13-year-olds)

Scevak, J. J., Moore, P. J., and Kirby, J. R. (1993). Training students to use maps to increase text recall. *Contemporary Educational Psychology,* 18, 401-413.

Study of effectiveness of training on ability to use accompanying maps to increase recall of history texbook passage showed higher scores for map-training group than no-map group on all recall measures. (High school students—Australian)

Schoon, K. J. (1989, March). *Misconceptions in the Earth sciences: A cross-age study.* Paper presented at the 62nd annual meeting of the National Association for Research in Science Teaching, San Francisco. (ERIC Document Reproduction Service No. ED 306076).

Study identified and classified misconceptions and analyzed their frequency with regard to several personological variables. Significant differences found for gender, race, educational level, and location. (5th-, 8th-, and 11th-graders and adults)

Slack, J. P., and Larkins, A. G. (1982). The effect of two instructional treatments on college students' topographic map skills achievement. *Journal of Social Studies Research,* 6(1), 13-16.

Assessment of the effectiveness of the lecture method ("instruction") vs. experiential learning ("practice") found that both methods raised subjects' topographic map reading skills, but that the latter was clearly more effective. (College students)

Smith, B. A. (1986). *Drill v. varied activity methods of teaching geographic place vocabulary.* Paper presented at the Southeast Regional Conference for the Social Studies, Charleston, SC. (ERIC Document Reproduction Service No. ED 313309).

Study comparing two instructional methods, drill vs. varied activities in teaching place vocabulary found that drill was more effective. (8th-graders)

Sorgman, M., Krall, F., and Uhlenberg, D. (1980). Interests of upper elementary students in human geography and their perceptions of effective learning environments. *Journal of Social Studies Research*, 4(1), 1-4.

Study found that interest in the "man-land" approach to geography education decreased with age, and that field-based learning experiences were seen as necessary to preserve interest. (4th- through 6th-graders)

Sports Science Education Programme (1990). *Developing navigational skills with young children: Investigating serial and conceptual approaches to the teaching of compass skills.* (Sports Science Education Programme Annual Report 1989/90). Liverpool, England: Liverpool University. (ERIC Document Reproduction Service No. ED 331668).

Results indicated that the conceptual approach was more effective than serial approaches in teaching compass and navigation skills, with no significant differences in achievement between boys and girls. (10-year-olds)

Steinbrink, J. E. (1970). *The effectiveness of advance organizers for teaching geography to disadvantaged rural Black elementary students.* Doctoral dissertation, University of Georgia.

Results of study indicate that students taught with advance organizers score significantly higher on a geography achievement test than students taught without. (5th- and 6th-graders)

Stoltman, J. P., and Goolsby, T. M. (1973). Developing map skills through reading instruction. *Journal of Geography*, 72, 32-36.

Test of a developmental map skills curriculum showed significant differences vis-à-vis the traditional curriculum on a standardized map skills test.

Straub, H. R., and Seaton, B. E. (1993). Relationship between gender and knowledge of U.S. state names and locations. *Sex Roles*, 28(9-10), 623-629.

Results of two experiments indicated a gender difference (favoring males) regarding ability to label state outlines correctly on a blank map but no difference in ability to list state names. (College students)

Waugh, M. L. (1986). *The effect of teacher involvement on student performance in a computer-based science simulation.* Washington, DC: U.S. Department of Education. (ERIC Document Reproduction Service No. ED 277560).

Study involved a computer simulation about volcanoes in an earth science class. Analysis of effects of teacher role (content and computer expert/facilitator vs. uninvolved monitor) during the simulation showed that learning was the same for both groups but that student attitudes were more positive with the helpful teacher. (8th-graders)

Weller, K. E. (1993). *The appropriateness of GIS instruction in grade six for teaching Kansas water resources.* Doctoral dissertation, Kansas State University.

Study showed that students at this level could learn effectively about natural resources from GIS.

Werner, R. J. (1990). *An experiment to determine the effectiveness of computer use in map projection instruction.* Doctoral dissertation, University of Minnesota.

Study investigated the effect of computer use on learning map projections and on attitude toward map projection learning, as well as time and cost factors involved with computer instruction. (College students)

Wilson, J. W. (1972). *The effect of three instructional designs: small group, peer teaching, and independent study on ninth grade geography students' ability to think critically.* Doctoral dissertation, University of Idaho.

Results of study show no significant effect of teaching method and no gender difference with regard to geography achievement. (9th-graders)

Formal Geography Learning: Reviews of Research

Bartz, B. (1970). Maps in the classroom. *Journal of Geography, 69,* 18-24.

Catling, S. (1984). Building less able children's map skills. *Remedial Education,* 19(1), 21-27.

Catling, S. J. (1978). The child's spatial conception and geographic education. *Journal of Geography,* 77(1), 24-28.

Cheek, H. N., and Muir, S. P. (1986). Mathematics and the map skill curriculum. *School Science and Mathematics,* 86(4), 284-291.

Courtney, T. D. (1986). The significance of the SOLO taxonomy for learning and teaching in geography. *Geographical Education,* 5(2), 47-50.

Crabtree, C. (1974). *Children's thinking in the social studies. Part I: Some factors of sequence and transfer in learning the skills of geographic analysis.* Los Angeles: University of California Press.

Daugherty, R. (1990). Assessment in the geography curriculum. *Geography,* 75(4), 289-301.

Emery, J. (1988). Videodisc, CD-ROM and the teaching of geography. In R. Gerber and J. Lidstone (Eds.), *Developing skills in geographical education* (8-17). (ERIC Document Reproduction Service No. ED 317470). Queensland, Australia: International Geographical Union Commission on Geographical Education/Jacaranda Press.

Fitzpatrick, C. (1990). Computers in geography instruction. *Journal of Geography,* 89(4), 148-149.

Fitzpatrick, C. (1993). Teaching geography with computers. *Journal of Geography,* 92(4), 156-159.

Forsyth, A. S., Jr. (1988). How we learn place location: Bringing theory and practice together. *Social Education,* 52(7), 500-503.

Gerber, R. (1987). A form-function analysis of school atlases. *Cartographica,* 24(1), 146-159.

Gerber, R. (1992). Is mapping in schools reflecting development in cartography and geographical information? In M. Naish (Ed.), *Geography and education: National and international perspectives* (194-211). London: University of London Institute of Education.

Gold, P. C. (1984). Cognitive mapping. *Academic Therapy*, 19(3), 277-284.

Golledge, R. G. (1981). The geographical relevance of some learning theories. In K. R. Cox and R. G. Golledge (Eds.), *Behavioral problems in geography revisited* (43-66). New York: Methuen.

Graves, N. J. (1982). The evaluation of geographical education. In N. J. Graves (Ed.), *New UNESCO source book for geography teaching* (313-363). Paris: UNESCO.

Hamill, L. (1985, April). *A model for information-based and computer-assisted learning in geography*. Paper presented at the annual meeting of the Association of American Geographers, Detroit. (ERIC Document Reproduction Service No. Ed 260959).

Haubrich, H. (1984). Research methods in evaluating the use of media in the teaching of geography. In N. J. Graves (Ed.), *Research and research methods in geographical education* (119-142). London: International Geographical Union/London University Institute of Education. (ERIC Document Reproduction Service No. ED 256705).

Hernando, A. (1984). Methods of researching the use of visual aids in the teaching of geography. In N. J. Graves (Ed.), *Research and research methods in geographical education* (98-118). London: International Geographical Union/London University Institute of Education. (ERIC Document Reproduction Service No. ED 256705).

Kent, W. A. (1992). The new technology and geographical education. In M. Naish (Ed.), *Geography and education: National and international perspectives* (163-176). London: University of London Institute of Education.

Larkins, A. G. (1984). Teaching children to associate names with places. *Georgia Social Science Journal*, 15(2), 8-10.

Larsen, B. (1983). Geography. In J. Whyld (Ed.), *Sexism in the secondary curriculum* (165-178). London: Harper and Row.

Liben, L., and Downs, R. (1988). Educating with maps: Part I. The place of maps. *Teaching Thinking and Problem Solving*, 11(1), 6-9.

Lyman, L., and Foyle, H. (1991). Teaching geography using cooperative learning. *Journal of Geography*, 90(5), 223-226.

Maier, J. (1993). Relating here to there: Globes and world maps as advance organizers. *Social Studies and the Young Learner*, 5(3), 9-11.

Marbeau, L. (1992). The need for curriculum research in geography: The case of France. In M. Naish (Ed.), *Geography and education: National and international perspectives* (80-94). London: University of London Institute of Education.

McClure, R. W. (1993). *A conceptual model for map skills curriculum development based upon a cognitive field theory philosophy*. Doctoral dissertation, Oklahoma state University.

Meyer, J. M. W. (1973). Map skills instruction and the child's developing cognitive abiliites. *Journal of Geography*, 72(6), 27-35.

Miller, J. W. (1985). Teaching map skills: Theory, research, practice. *Social Education*, 49(1), 30-33.

Mosenthal, P. B., and Kirsch, I. S. (1990). Understanding general reference maps (understanding documents). *Journal of Reading*, 34(1), 60-63.

Muir, S. P. (1985). Understanding and improving students' map reading skills. *Elementary School Journal*, 86(2), 207-216.

Muir, S. P., and Cheek, H. N. (1983, October). *A developmental mapping program integrating geography and mathematics*. Paper presented at the annual meeting of the National Council for Geographic Education, Ocho Rios, Jamaica. (ERIC Document Reproduction Service No. ED 238796).

Muir, S. P., and Cheek, H. N. (1991). Assessing spatial development: Implications for map skill instruction. *Social Education*, 55(5), 316-319.

Muir, S. P., and Frazee, B. (1986). Teaching map reading skills: A developmental perspective. *Social Education*, 50, 199-203.

Naish, M. C. (1982). Mental development and the learning of geography. In N. J. Graves (Ed.), *New UNESCO source book for geography teaching* (16-54). Paris: UNESCO.

Phipps, W. E. (1987). Cartographic ethnocentricity. *Social Studies*, 78(6), 260-263.

Picker, R. D. (1965). Geography and the learning process: A methodological review. *Journal of Geography*, 64, 340-345.

Richards, L. (1983, October). *Piagetian theory as an organizer for geographic skills and experiences*. Paper presented at the annual meeting of the National Council for Geographic Education, Ocho Rios, Jamaica. (ERIC Document Reproduction Service No. ED 241386).

Sabaroff, R. E. (1957). *A framework for developing map skills in primary grade social studies*. Doctoral dissertation, Stanford University.

Sandford, H. A. (1988). School-based research into pupils' mapwork difficulties and their solution. In R. Gerber and J. Lidstone (Eds.), *Developing skills in geographical education* Queensland, Australia: International Geographical Union Commission on Geographical Education. (ERIC Document Reproduction Service No. 319644).

Saveland, R. N. (1983). Map skills around the world; How to test and diagnose place vocabulary capabilities. *Social Education*, 47(3), 206-211.

Schrettenbrunner, H. (1986). Research perspectives for the empirical didactics of geography. In A. Hernando (Ed.), *Geographical education and society.* (54-67). Sitjes, Spain: International Geographical Union Commission on Geographical Education. (ERIC Document Reproduction Service No. ED 284815).

Slater, F. (1982). *Learning through geography.* London: Heinemann.

Slater, F. A., and Spicer, B. (1982). Studying relationships and building models through the analysis of maps and photographic evidence. In N. J. Graves (Ed.), *New UNESCO source book for geography teaching* (206-253). Paris: UNESCO.

Sunal-Szymanski, C. (1987). Mapping for the young child. *Social Studies,* 78(4), 178-182.

Turley, T., and Atkinson, G. (1984). Geographic skills: A research-based sequence for grades one to nine. *The History and Social Science Teacher,* 19(4), 101-105.

Wandersee, J. H. (1990). Concept mapping and the cartography of cognition. *Journal of Research in Science Teaching,* 27(10), 923-936.

White, K. L., and Simms, M. (1993). Geographic information systems as an educational tool. *Journal of Geography,* 92(2), 80-85.

Winn, W. (1993). An account of how readers search for information in diagrams. *Contemporary Educational Psychology,* 18(2), 162-185.

Wise, N., and Kon, J. H. (1990). Assessing geographic knowledge with sketch maps. *Journal of Geography,* 89(3), 123-129.

Wright, D. R. (1988). Applied textbook research in geography. In R. Gerber and J. Lidstone (Eds.), *Developing skills in geographical education* Queensland, Australia: International Geographical Union Commission on Geographical Education/Jacaranda Press. (ERIC Document Reproduction Service No. ED 319644).

Affective Geography Learning

Carnie, J. (1972). Children's attitudes to other nationalities. In N. Graves (Ed.), *New movements in the study and teaching of geography* (121-134). London: Temple Smith.

Review of research on attitudes of children, from preschool to secondary school. (British)

Carnie, J. (1973). The development of national concepts in junior school children. In J. Bale, N. Graves, and R. Walford (Eds.), *Perspectives in geographical education* (101-118). Edinburgh, Scotland: Oliver and Boyd.

Review of research presents a developmental sequence for national concepts related to general cognitive and affective development. (British)

Currin, C. B. (1973). *American secondary school students and foreign culture areas: An analysis of the interrelationships of knowledge, attitude, image, and conceptual level using Africa as a case study*. Doctoral dissertation, Syracuse University.

Study found no significant relationship between factual knowledge of a foreign culture area and attitude toward that area; in fact, no single variable or set of variables was found to predict attainment of positive attitudes toward other peoples or countries.

Haddon, J. (1960). A view of foreign lands. *Geography*, 45(4), 286-289.

Investigation of words and phrases generated by young people that characterize foreign countries (Australia, U.S., France, South Africa). (13- to 16-year-olds—British)

Hibberd, D. (1983). Children's images of the Third World. *Teaching Geography*, 8, 68-71.

Survey study generated words and phrases that characterize developing countries in the minds of young people. Also surveyed subjects' suggested ways to improve developing countries' standards of living (most commonly mentioned: more doctors). (12- to 15-year-olds—British)

Jahoda, G. (1963a). The development of children's ideas about country and nationality. Part II: National symbols and themes. *British Journal of Educational Psychology*, 33, 143-153.

Investigation of children's recognition and understanding of national symbols of home country (Scotland) and neighboring countries (England, Ireland), categorized into "geographical stages," showed great increases with age. (6- to 11-year-olds—Scottish)

Jahoda, G. (1963b). The development of children's ideas about country and nationality. Part I: The conceptual framework. *British Journal of Educational Psychology*, 33, 47-60.

Survey study of random sample (stratified by social class, age and gender) to assess the degree of emergence of national identification. Proposed four "geographical stages" in this development. Employed a test of spatial representation of geographical relationships among city, region, and country. (6- to 11-year-olds—Scottish)

Jahoda, G. (1964). Children's concepts of nationality: A critical study of Piaget's stages. *Child Development*, 35, 1081-1092.

Replication of Piaget (1951). Study refuted Piaget's assertion that development proceeds from comprehension of spatial relations to comprehension of nationality; rather, the two developmental sequences are overlapping and partially concurrent. (6- to 11-year-olds—Scottish)

James, H. E. O., and Tenen, C. (1951). Attitudes towards other peoples. *International Social Science Bulletin*, 3, 553-561.

Study consisted of interviews of subjects to assess their attitudes toward a foreign people (Africans) followed by an educational intervention (visit by foreign person/interpersonal interaction) to change any negative attitudes or misconceptions. Results indicate that the intervention strategy was largely successful. (11- to 15-year-olds—British)

Johnson, N. B., Middleton, M. R., and Tajfel, H. (1970). The relationship between children's preferences for and knowledge about other nations. *British Journal of Social and Clinical Psychology*, 9, 232-240.

Study found a curvilinear relationship between preferences for and knowledge about other nations, although subjects knew more about countries they liked a lot than those they disliked a lot. (7- to 11-year-olds—British)

Knight, C. L. (1982). *An international study of relationships between geographic knowledge of students and their attitude to other nationalities*. Doctoral dissertation, University of Georgia.

Survey study found no significant relationship between attitudes toward countries in the Americas and geographic knowledge about them. However, it did find a strong relationship between attitudes and country of residence, sex, and educational expenditure per capita. (Secondary school students—13 countries)

Middleton, M. R., Tajfel, H., and Johnson, N. B. (1970). Cognitive and affective aspects of children's national attitudes. *British Journal of Social and Clinical Psychology*, 9, 122-134.

Experimental study using random sample stratified on age, gender, and social class, found that children's preference for their own country and ability to adopt the point of view of others both increase with age, but that this perspective-taking ability is affected by children's attitudes toward peoples from other countries. Also found strong relationship between social class and attitudes toward one's own and other countries. No gender differences. (7- to 11-year-olds—British)

Piaget, J., and Weil, A.-M. (1951). The development in children of the idea of the homeland and of relations with other countries. *International Social Science Bulletin*, 3, 561-578.

Interview study concluded that the child's discovery of homeland and understanding of other countries is a process of transition from egocentricity to reciprocity. (4- to 5-year-olds and 14- to 15-year-olds—Swiss)

Pike, L. W., and Barrows, T. S. (1979). *Other nations, other peoples: A survey of student interests, knowledge, attitudes, and perceptions*. Washington, DC: U.S. Government Printing Office.

Extensive survey study showed clear age and gender differences in interests (which countries respondents would like to visit, study, live in), knowledge, and attitudes/perceptions. Includes survey of teachers to assess perceptions of items greatly influencing students' attitudes and opinions toward other countries and peoples. Provides comprehensive baseline data for future studies.(4th-, 8th-, and 12th-graders)

Porter, P. W. (1987). In Dunkelsten Afrika: Africa in the student mind. *Journal of Geography*, 86(2), 51-59.

Summary of 30 years of data collected on students' knowledge and misconceptions about Africa. (College students)

Robinson, R. (1987). Exploring students' images of the developing world. *Geographical Education*, 5(3), 48-52.

Study analyzed students' reactions to a photograph of an Indian village, based on the theory of constructive alternativism. (British)

Schmidt, N. (1975). *Fourth, fifth, and sixth grade students' global orientations: A descriptive study*. Doctoral dissertation, University of California, Los Angeles.

Survey study found that respondents knew very little about their world environment and that those who knew more tended to be less chauvinistic.

Stillwell, R., and Spencer, C. (1974). Children's early preferences for other nations and their subsequent acquisition of knowledge about those nations. *European Journal of Social Psychology*, 3(3), 345-349.

Study results suggest a linear relationship between preferences for other nations and knowledge about them. After a week of informal exposure to educational wall displays about countries, knowledge of both disliked and liked countries increased significantly, although both before and after the treatment students' knowledge was greater for countries they liked. (8- to 9-year-olds—British)

Stoltman, J. P. (1972, August). *Territorial decentration and geographic learning*. Paper presented at the International Geographical Congress Commission on Geography in Education, Quebec City, Canada. (ERIC Document Reproduction Service No. ED 071933).

Test of Piaget's theory of territorial decentration and consequent development of a more inclusive world view between ages six and twelve showed later onset of decentration than Piaget (Swiss) or Jahoda (Scottish) found; significant differences for race; no significant differences for gender or rural-urban residence. Offers cultural differences as explanation of discrepancy. (1st- through 6th-graders)

Stoltman, J. P. (1976). Children's conception of territory: United States. In J. P. Stoltman (Ed.), *International research in geographical education: Spatial stages development in children and teacher classroom style in geography* (Research reports prepared in conjunction with the 23rd Congress of the International Geographical Union). Kalamazoo: Western Michigan University.

See Stoltman (1972)

Tajfel, H. (1967). *A study of cognitive and affective attitudes*. Stanford, CA: Center for Advanced Study in Behavioral Science. (ERIC Document Reproduction Service No. ED 031112).

Study investigated attitudes toward foreign countries, affiliation with own country, perception of similarities and differences of foreign countries, and perception of relations between nationals and foreign countries. (6- to 12-year-olds—several nations)

Towler, J., and Price, D. (1976). The development of nationality and spatial relationship concepts in children: Canada. In J. P. Stoltman (Ed.), *International research in geographical education: Spatial stages development in children and teacher classroom style in geography (Research reports prepared in conjunction with the 23rd Congress of the International Geographical Union)* (79-88). Kalamazoo: Western Michigan University.

Survey study examined development of concept of nationality in four areas: geographic stages, nationality stages, country stages, and foreignness stages. Data analysis supports Piaget's developmental stages. Also investigated respondents reasons for liking or disliking a country. (6-, 9- and 11-year-olds—Canadian)

Wiegand, P. (1991). The 'known world' of primary school children. *Geography*, 76(2), 143-50.

Descriptive study of which parts of the world are better known to which subgroups of children than others, with possible explanations. (7- to 11-year-olds—British)

Overview: Geography Education

Anderzhon, M. L. (1963). *A selected bibliography of geography education for curriculum committees*. (Special Publication No. 7). Indiana, PA: National Council for Geographic Education.

Bacon, P., and Kennamer, L. (1967). Suggestions for research in geographic education. In P. Bacon and L. Kennamer (Eds.), *Research needs in geographic education: Suggestions and possibilities* (41-46). Normal, IL: National Council for Geographic Education.

Bale, J., Graves, N., and Walford, R. (Eds.). (1973). *Perspectives in geographical education*. Edinburgh, Scotland: Oliver and Boyd.

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Postscript on Methodology

The compilation process for this bibliography began with a thorough examination of the best existing bibliographies on research in geography education, namely those of Stoltman (1991), Gregg and Leinhardt (1994), and Downs (1988, 1994). The structure of this bibliography became evident from that examination: the preponderance of references fell into the categories of spatial learning, map learning, formal classroom learning, and affective learning. Those excellent bibliographies also led me to other sources with useful reference lists.

Concurrent with following the branches on the research tree in that manner, I began a thorough search of the computer databases ERIC, *Psychology Abstracts*, and *Dissertation Abstracts*. These provided valuable references and abstracts.

The third method used to gather references was personal correspondence via mail and modem. In addition to prominent geography educators in this country, I contacted several international geography education organizations that provided several useful references.

Once lists of titles had been accumulated and categorized, the process of locating the articles, reading and annotating them, began. Computer software designed for the creation of bibliographies was invaluable in this process.

Arriving at the final bibliography involved a good deal of redefining categories (for example, distinguishing between reviews of research in formal geography learning and general geography education works) and closely examining criteria for inclusion. In particular, it was difficult to decide whether to include many narrowly-focused, psychology-based studies of spatial learning and studies related to learning in the social studies but not in geography specifically. I found many studies that were primarily surveys of geographic knowledge levels but which could also conceivably cast light on the learning process: most of these were not included.

In conclusion, let me say that, though the author may be exhausted, this bibliography is not exhaustive. My aim was to make as complete a survey as possible of research relevant to how people learn geography. Gaps remain, for which I take full responsibility. My hope is that this work is substantial enough to be of use to anyone sincerely interested in geography education. Comments from readers are welcomed.

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